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Mineral Development Division
Department of Mines and Energy
Government of Newfoundland and Labrador

CURRENT RESEARCH

Report 82-1
C.F. O'Driscoll and R.V. Gibbons (Editors)

St. John's, Newfoundland
1982

Editor R.V. Gibbons

Review Geologist C.F. O'Driscoll
B.H. O'Brien

Text editing and typesetting

C. Gullage
T. Parsons

Typing

B. French
E. Fost

Drafting Supervisor

K. Byrne

Drafting

D. Leonard
T. Paltanavage

Acknowledgements

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PREFACE

This publication is the ninth in the Mineral Development Division's annual Report of Activities series.

The past year has been a significant and historic one for the Division, in that it has seen the completion of regional geochemical surveys on the island of Newfoundland, and the completion of field work under the Canada-Newfoundland Mineral Development Subsidiary Agreement. Regional geochemical studies were begun in Newfoundland in 1972, with a pilot project in the Daniel's Harbour and Point Leamington areas. This year's survey of the Great Northern Peninsula thus completes a 10-year program of regional lake sediment surveys in insular Newfoundland.

The Mineral Development Division has been operating under the Canada-Newfoundland Mineral Development Subsidiary Agreement since 1976. This Agreement provided for a five-year program of geoscientific studies, to be funded on a 90% Federal - 10% Provincial cost-shared basis. The Agreement ends on March 31, 1982. The 1981 field season thus marked the end of field work under this cost-shared program.

The past five years under the Mineral Development Agreement have been very productive for the Mineral Development Division; the Division has grown considerably over that period and has made significant contributions to the geoscientific data base for Newfoundland. Although the Mineral Development Agreement will not be renewed in its present form, negotiations are continuing with the Federal Department of Energy, Mines and Resources toward a new co-operative geoscientific program, and the Province has provided thirteen new positions for the Division. There is thus every indication that the work begun under the Agreement will continue.

B.A. Greene
Director
Mineral Development Division
1982 02 11

Any reader who would like to write a rebuttal to, or discussion of, any report contained in this volume is invited to submit it to the editor by November 1, 1982, to be considered for inclusion in Report 83-1.

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NEWFOUNDLAND MAPPING SECTION

Western Platform

1. **Svend Stouge** continued stratigraphic studies initiated by **Ian Knight** on the Cambro-Ordovician rocks of the Great Northern Peninsula and mapped a portion of the Hare Bay area.
2. **Richard Hyde** carried out check traverses in selected areas of the Deer Lake Basin. A final report is in progress.
3. **Ian Knight's** final memoir of the Carboniferous stratigraphy and sedimentology of the Bay St. George basin is approaching the final editing stage.

Central Mobile Belt

4. **Baxter Kean** carried out reconnaissance work in parts of west central Newfoundland. A final report integrating all previous work is in progress.
5. **Steve Colman-Sadd** and **H.A.J. Russell** mapped at 1:50,000 scale in the Miguels Lake (2D/12) map area.
6. **Frank Blackwood** and **L. Green** continued 1:50,000 scale mapping south of Gander Lake in the Great Gull Lake (2D/6) and Dead Wolf Pond (2D/10) map areas.
7. **Lesley Chorlton** did check work in the Grandy's Lake (110/15) map area. A preliminary report is in progress.
8. **Jim Hibbard** did reconnaissance work on the Baie Verte Peninsula and is completing a final memoir of that area.
9. **Ron Smyth** mapped the Cambro-Ordovician and Silurian rocks and Devonian granitoids in southern White Bay.
10. **Lawson Dickson** carried out detailed mapping in the southern contact zone of the Ackley Granite in the Long Harbour and Big Blue Hill Pond areas.

Avalon Zone

11. **Sean O'Brien** is preparing a colored 1:250,000 map of the Belleoram and St. Lawrence map areas. A preliminary blue-line open file has been released. Reports for the Baine Harbour - Point Enragee (1M/6-7) and Terrenceville - Gisborne Lake (1M/10-15) map areas are in progress.

LABRADOR MAPPING SECTION

Central Mineral Belt

12. **Bruce Ryan** completed 1:100,000 scale mapping of the Eastern Central Mineral Belt north of Kaipokok Bay.

Grenville Province

13. **Andy Thomas** completed mapping in the Red Wine Mountains area. A memoir is in progress.

14. **Charles Gower** mapped in the Cartwright region of the Grenville Province in parts of 13G and 13H map areas.

15. **Richard Wardle** mapped in the region around Churchill Falls in parts of 23H and 13E map areas.

16. **Ges Nunn** continued 1:100,000 scale geological mapping in the Grenville Front Zone concentrating on 13L (southwest) map area.

Northern Labrador

17. **John Hill** did reconnaissance work inland from Davis Inlet in an area which straddles the southwestern boundary of the Nain Igneous Complex and the Churchill Structural Province. A final report is in progress.

GEOCHEMISTRY SECTION

18. **Jim Butler** continued the geochemical lake sediment program in northwestern Newfoundland.
19. **John McConnell** continued geochemical and geophysical studies on base metal anomalies in the Labrador Trough near Schefferville.

MINERAL DEPOSITS SECTION

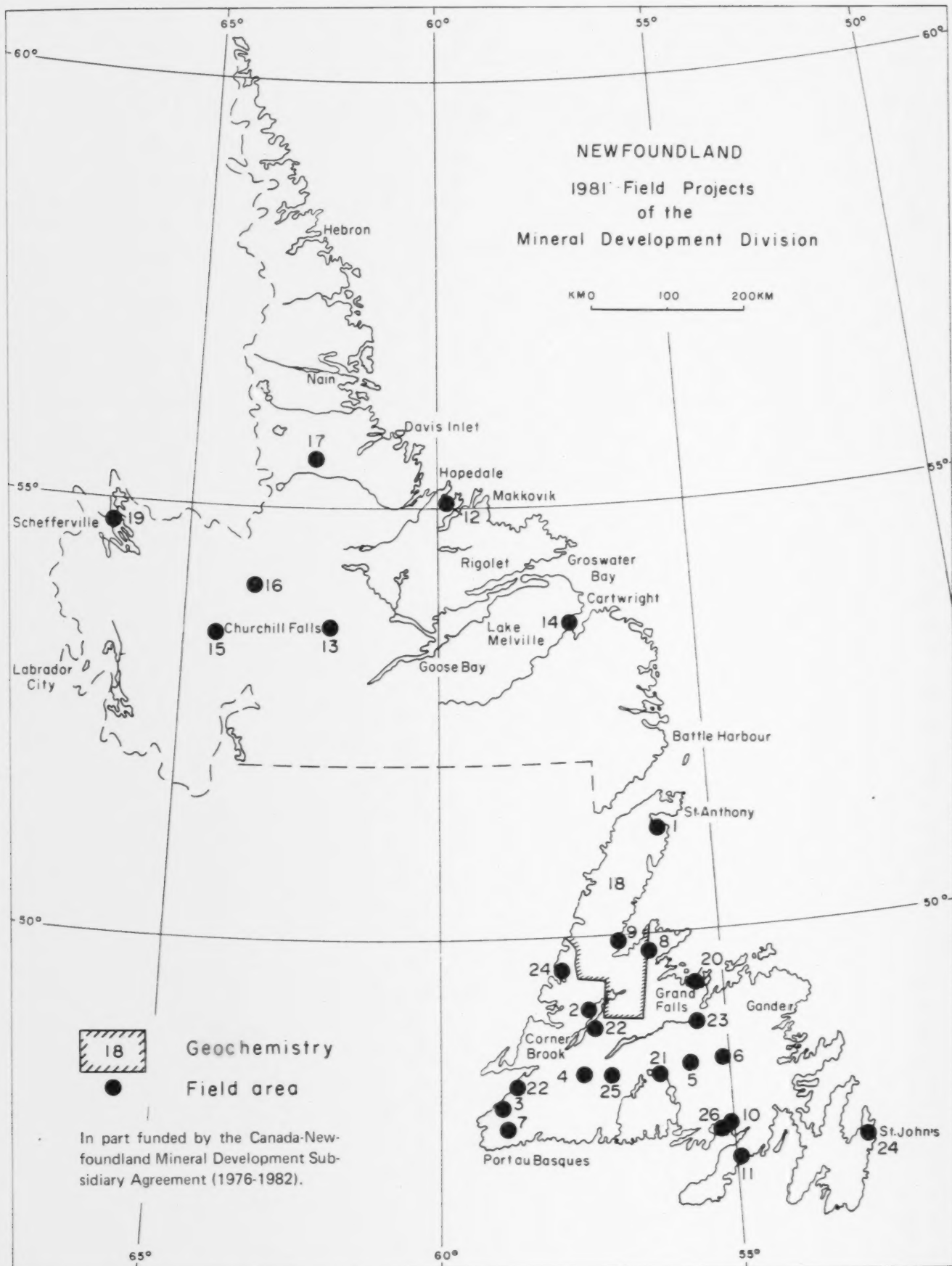
20. **Paul Dean** and **Jamie Meyer** carried out a metallogenic study of mid-Ordovician cherts and shales in the Notre Dame Bay area.
21. **Scott Swinden** continued the regional economic geological study of parts of the Central Mobile Belt. Field work in 1980 was concentrated in the Great Burnt Lake - Cold Spring Pond area.
22. **Ambrose Howse** carried out coal assessment in the St. Georges Bay and Deer Lake Carboniferous basins.
23. **Steve Tomlin** and **Dave Watson** continued the assessment of memorial and dimension stone potential for Insular Newfoundland. Their work concentrated in the Bishops Falls area with brief visits to the Stephenville, Fogo Island and Hermitage areas.

ENVIRONMENTAL GEOLOGY SECTION

24. Detailed aggregate assessment was done by **Fred Kirby** in the St. John's Urban Region and **Randy Ricketts** in the Gros Morne area.
25. **Byron Sparkes** carried out surficial and glacial mapping of the Snowshoe Pond map area in the Central Mobile Belt.
26. **Doug Vanderveer** did preliminary glacial mapping in the southern part of the Ackley Granite.

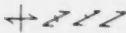
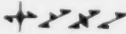
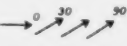
PUBLICATIONS AND INFORMATION SECTION

- **Alvin Harris** joined this section during the year and is continuing the program of collection and storage of exploration drill core.



LIST OF SYMBOLS USED ON GEOLOGICAL MAPS AND FIGURES

Drift covered area	
Rock outcrop, area of outcrop, probable outcrop, float, frost-heaved rock	
Geological boundary (defined, approximate, assumed, gradational, dip indicated)	
Intrusive contact with younger unit indicated	
Unconformity (defined, assumed)	
Limit of geological mapping	
Limit of area surveyed with aircraft	
Bedding, tops known (horizontal, inclined, vertical, overturned)	
Bedding, tops unknown (horizontal, inclined, vertical, dip unknown)	
Bedding, general trend (dip unknown, top unknown; dip and top known; dip known, top unknown)	
Bedding, estimated dip (gentle, moderate, steep)	
Igneous flow banding (inclined, vertical)	
Igneous intrusive sheets (inclined, vertical)	
Primary igneous layering, tops known (horizontal, inclined, vertical, overturned)	
Primary igneous layering, tops unknown (horizontal, inclined, vertical)	
Strike and dip of pillows, tops known (horizontal, inclined, vertical, overturned)	
Strike and dip of pillows, tops unknown (horizontal, inclined, vertical)	
Primary igneous mineral lamination (inclined, vertical)	
Primary igneous mineral lineation (inclined, vertical)	

Flow Contact	
Zone containing xenoliths	
Zone of intrusive agmatite	
Roof pendant (unit number indicated; too small to map separately)	
Zone containing autoliths	
Breccia of various origins	
Slaty cleavage (horizontal, inclined, vertical, dip unknown)	
Strain-slip cleavage (horizontal, inclined, vertical, dip unknown)	
Schistosity, cleavage, foliation; used where ages of foliation are indicated on the map (horizontal, inclined, vertical)	
Schistosity of unknown age	
S ₁	
S ₂	
Schistosity, gneissosity, cleavage, foliation, general trend	
Gneissic foliation (horizontal, inclined, vertical, dip unknown)	
Gneissic banding (horizontal, inclined, vertical)	
Axial plane of minor fold (inclined, vertical, dip unknown)	
Lineation (horizontal, inclined, inclined but plunge unknown, vertical)	
Type of lineation denoted by letter:	
Mineral lineation	
S intersections	
Microcrenulations	
Boudin axes	
Deformed clasts	
Igneous inclusions	
Rodding, mullion structure	
Metamorphic aggregates	
Deformed pillows	

Age of lineation and of minor fold axes

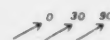
Lineation of unknown age

L₁

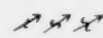
L₂



Axes of minor folds (horizontal, inclined, vertical)



Sense of vergence of minor structures (used with minor fold axes symbol or lineation S intersection symbol; read looking along the arrow)



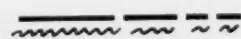
Structural trend (from aerial photographs)



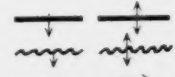
Lineament (from aerial photographs)



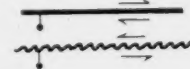
Fault (defined, approximate, assumed)



Fault (inclined, vertical)



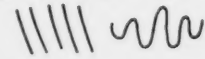
Fault (solid circle indicates downthrown side, arrows indicate relative movement)



Thrust fault (teeth in direction of dip; defined, approximate, assumed) (teeth indicate upthrust side)



Zone of numerous imbricate thrust faults



Fault zone, shear zone (width indicated)



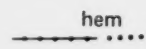
Tectonic slide



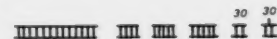
Vein fault (defined, assumed)



Mineralized bed or seam (hematite)



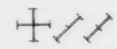
Dike, vein, or stockwork (defined, approximate, assumed; unit number and dip indicated)



Joint (horizontal, inclined, vertical)

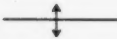
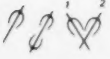
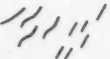
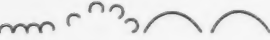


Sheeted dikes (horizontal, inclined, vertical)



Anticline (defined, approximate, assumed)



Antiform	
Syncline (defined, approximate, assumed)	
Synform	
Anticline and syncline (overturned)	
Anticline or syncline (arrow indicates plunge)	
Antiform or synform	
Glacial striae (direction of ice movement known, unknown). Numbers indicate relative age, 1 being the oldest	
End moraine	
Minor moraines, rib moraines, washboard moraines, "annual" moraines, till ridges transverse to ice flow (irregular, straight)	
Drumlins, drumlinoid ridges (direction of ice movement known, unknown)	
Crag and tail hills and ramps	
Glacial linear feature	
Pingo or palsen	
Esker (direction of flow known, unknown)	
Esker (continuous, discontinuous)	
Raised beaches	
Limit of marine or lacustrine submergence (well marked, assumed)	
Dunes	
Area of sand dunes	
Buried valley	

Abandoned river channel, spillway, ice-marginal channels, rill patterns, etc.	
Landslide scar	
Escarpment and cirques	
Fossil locality	
Locality where age has been determined, in millions of years	
Ice divide	
Land system boundary	
Location of measured section	
Gravel pit or quarry (active, abandoned)	
Borrow pit (active, abandoned)	
Rock dump or tailings	
Rock quarry (active, abandoned)	
Mine (lead, zinc)	
Mine (lead, zinc; abandoned)	
Mineral prospect; mineral occurrence (manganese)	
Placer deposit (gold)	
Show of oil and gas (abandoned)	
Show of gas (abandoned)	
Gas producer	
Oil producer	
Oil and gas producer	

Location of drilling	○
Dry (abandoned)	✧
Water source or disposal	⦿
Shearing and dip	
Salt spring	ss Q
Hot spring	hs Q
Mineral isograd	■ ■ ■ ■ ■ ■ ■ ■
Other alternatives when more than one	□ ○ ● ▲ ★
Shaft, raise, winze	■ ■ ■
Shaft (abandoned)	■
Trench	
Open cut; axial	
Adit or tunnel	└ ┘
Adit or tunnel (caved)	└/ ┘/
Borehole	● BH ● BH 3
Diamond drill hole	● DDH
(Surface projection of geology inferred)	—○
Sinkhole	○ SH
Gossan	
Trace of coal seam	—— —

ADDITIONAL SYMBOLS

<i>Geological boundary (geophysically defined)</i>	
<i>Geophysical conductor</i>	
<i>Roche moutonnee</i>	
<i>Meltwater channel</i>	
<i>Sinkhole</i>	SH
<i>Open pit, mine or quarry</i>	
<i>Locality where age has been determined, in thousands of years before the present</i>	Ⓕ 125
<i>Till fabric (direction known, unknown, known plus cross fabric)</i>	

SAMPLE LOCALITIES (SURFICIAL)

<i>Glacial till</i>	●	<i>Clay</i>	+
<i>Gravel</i>	⊗	<i>Organic</i>	✱
<i>Sand</i>	○	<i>Rock</i>	Ⓓ
<i>Silt</i>	■	<i>Pleistocene fossil</i>	Ⓕ

GEOLOGY OF THE AREA SOUTHWEST OF HARE BAY, GREAT NORTHERN PENINSULA

by

Svend Stouge and Steve Godfrey*

INTRODUCTION

Mapping, at a scale of 1:50,000, of the Cambro-Ordovician clastic carbonate sequence in the Hare Bay south area (Figure 1) was completed during 1981; part of it had previously been mapped in 1979 (Knight, 1980a; Knight & Saltman, 1980) and in 1980 (Stouge, 1981). The map area also includes the sedimentary rocks within the "White Arm Window" (Smyth, 1973). The work represents the culmination of the "Daniel's Harbour mapping project" begun in 1976 (Knight, 1977a, b, 1978, 1980a; Knight & Edwards, 1978a, b; Knight & Snow, 1979; Knight & Saltman, 1980; Stouge, 1981).

The Lower Paleozoic stratigraphy of southern Hare Bay has previously been studied by Cooper (1937), Smyth (1973), with additional information by Williams (1975). Betz (1939) mapped the rocks in the southern part of the area for the Newfoundland Government. Bostock *et al.* (1976) presented 1:125,000 scale maps of the region. Knight (1980a, b), Knight & Saltman (1980) and Stouge (1981) reported on and revised the stratigraphy of the Cambrian to Middle Ordovician platformal sequence.

LOCATION AND ACCESS

The map area is located in White Bay East District of the Great Northern Peninsula. The area includes the southern shore of, and islands within, Hare Bay (Figure 1). Supplies and services necessary for maintenance of field camps are available from the communities of Englee and Roddickton in the south and Main Brook in the north.

The Plum Point road, which connects with the Great Northern Peninsula highway, is located in the southern part of the area, where it connects with the Roddickton and Main Brook roads. Smaller roads branch off the Main Brook-Roddickton road to Croque, St. Julien's (Grandois) and Conche. Wood roads (Road 16 and 18) provide access from Main Brook and the Main Brook road to the western edge of the area along the north side of Salmon River. Coles Pond can be reached by wood roads from the Conche Road and from the Main Brook road and access to the northeast side of the White Arm Window is possible by a north trending logging road. The remainder of the area is accessible either by boat or by aircraft; mobility is enhanced by the Salmon River, which in wet weather is navigable from Rubes Steady to Main Brook. Coastal exposures are accessible by boat. Float-plane service is available in Main Brook.

GEOLOGIC SETTING

The area is entirely within the Humber Zone of the Newfoundland Appalachians (Williams, 1979).

The following tectonic elements are present within the map area (Figure 2):

(1) an inlier of Precambrian crystalline rocks of the Grenville Basement;

(2) a Cambrian-Ordovician siliciclastic-carbonate sequence unconformably overlying the crystalline inlier;

(3) an easterly derived, Middle Ordovician quartzofeldspathic flysch sequence that locally conformable

* Present address: Department of Geology, Memorial University of Newfoundland, St. John's.

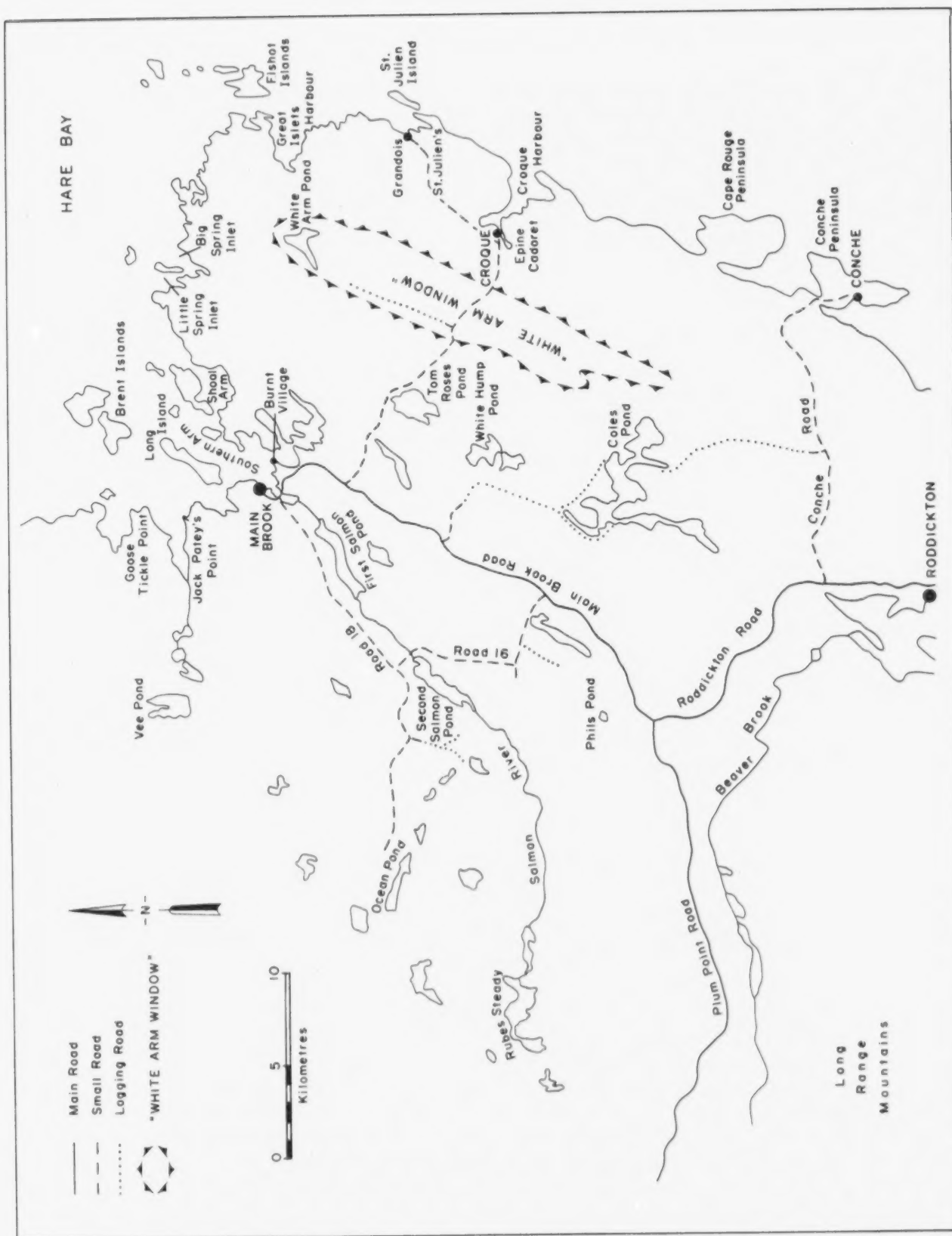


Figure1 – Location Map of the Hare Bay South area.

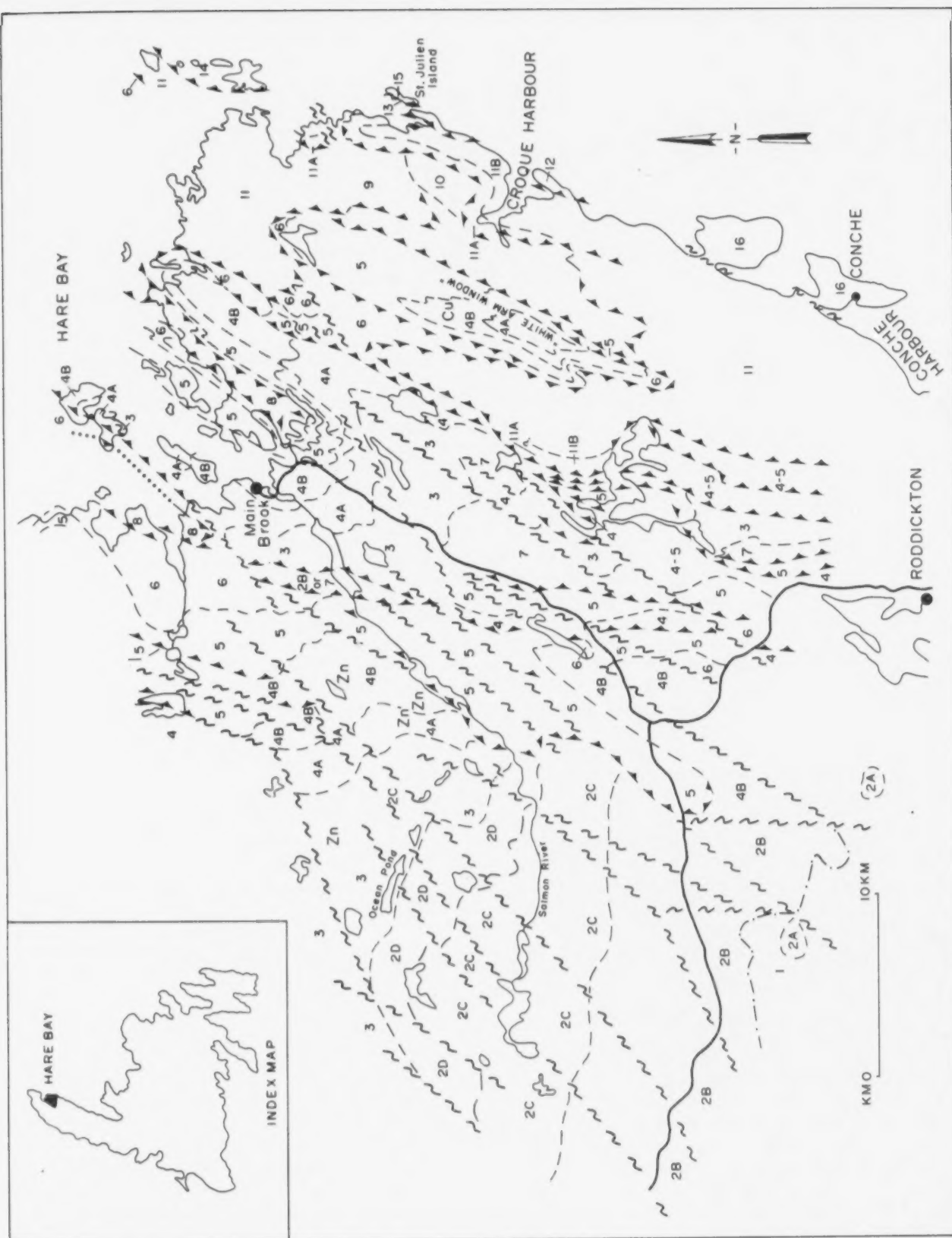


Figure 2 - Geological sketch map of the Southwestern Hare Bay area.

LEGEND

COVER ROCKS

CARBONIFEROUS

- 16 Gray and brown bedded sandstone, siltstones and shales with plant fossils; red conglomerates.

SILURIAN

- 15 Red polymictic conglomerate and minor graywacke.

ALLOCHTHONOUS ROCKS

PRECAMBRIAN-LOWER CAMBRIAN

St. Anthony Slice assemblage

- 14 Goose Cove schist and Green Ridge amphibolite: Amphibolite and greenschist derived from tuffs, mafic agglomerates and volcanic rocks. Minor black and green pelitic schist and marble.

Grandois Slice

- 13 Grandois Group (Irish limestone): Sandy limestone (lime turbidite)

Maiden Point Slice Assemblage

- 12 Croque Head Slice: Coarse to fine grained sandstone and conglomerate; minor volcanic rocks.
- 11 Maiden Point Slice: Coarse to fine grained sandstone and conglomerate; minor volcanic rocks.
- 10 Melange: Black and bright green shales with ultramafic blocks.
- 9 Epine Cadoret Slice: Black and gray slates; minor sandstones.

?LOWER ORDOVICIAN

Northwest Arm Formation

- 8 Black and bright green shales with blocks of green chert, parted limestone, dolostone, pillow lava and massive bedded, coarse sandstones. Generally disrupted to form melange.

PARAUTOCHTHONOUS ROCKS

LOWER CAMBRIAN

- 7 Gray, white weathering shale; ribbon limestone with dolomite laminae; oolitic and oncolitic limestone; minor stromatolitic mounds. Equivalent to Unit 2.

AUTOCHTHONOUS ROCKS

MIDDLE ORDOVICIAN

- 6 **Goose Tickle Formation:** Green-gray pyritiferous siltstone and shale; minor brown weathering sandstone and conglomerate at the top; black shale with limestone nodules/beds.
- 5 **Table Head Formation:** Massive bedded micrite, biomicrite; nodular bedded micrite-biosparite and hemipelagic limestone, shaly at the top; black nodular chert common in massive bedded micrite.

LOWER-MIDDLE ORDOVICIAN

- 4 **St. George Group:** Bioturbated micrite, dolomitic bioturbated micrite, interbedded massive dolostone, finely laminated dolostone and bioturbated limestone; minor dolostone; stromatolite and sponge mounds common; chert abundant.

CAMBRIAN?-LOWER ORDOVICIAN

- 3 **Port au Port Group equivalents:** Massive bedded dolostone, gray homogeneous, yellow weathering; dark gray, brown dolostone, chert, stromatolitic mounds; minor shale, finely laminated dolostone and vuggy dolostone; massive bedded dark bluish gray micrite at the base.

EOCAMBRIAN?-CAMBRIAN

- 2 **Labrador Group:** White quartzite and conglomerate; reddish brown basalt and agglomerate; red to pink arkose, minor conglomerate; brown to gray shale/minor crossbedded sandstone, lime nodules and limestone beds. Fossiliferous (*Salterella* and trace fossils).

PRECAMBRIAN

- 1 **Long Range Complex:** Granodiorite; granite, some amphibolite and foliated granodiorite.

overlies the carbonate platformal rocks; (4) a parautochthonous assemblage of clastic and carbonate sediments; (5) allochthonous slices of clastic sedimentary and volcanic rocks of the Hare Bay Allochthon (Gillis, 1966; Smyth, 1971, 1973). The slices in the map area are referred to as the Epine Cadoret Slice, Northwest Arm Slice, Maiden Point Slice assemblage, Grandois Slice and St. Anthony Slice assemblage.

BASEMENT ROCKS (PRECAMBRIAN)

UNIT 1

Precambrian crystalline basement underlies the Long Range Mountains in the southwesternmost extremity of the map area. Gneiss complexes, a variety of granites and other intrusive rocks are predominant lithologies of the Grenville Orogen. The rocks are cut by a swarm of northeast trending basic dikes (Williams *et al.*, 1974).

AUTOCHTHONOUS ROCKS (?PRECAMBRIAN-MIDDLE ORDOVICIAN)

The Eocambrian? to Middle Ordovician strata are collected in five groups/formations (Units 2-6) (Table 1). The sequence is divided into the Eocambrian?-Lower Cambrian to Middle Cambrian Labrador Group (Unit 2), carbonates of the Port au Port Group (Knight, 1980b) of Middle to Upper Cambrian and possibly Lower Ordovician age (Unit 3), the St. George Group of Lower to Middle Ordovician age (Unit 4), and the Middle Ordovician Table Head (Unit 5) and Goose Tickle (Unit 6) Formations. The Goose Tickle Formation is structurally overlain by a melange unit (Unit 8) which forms the base of the allochthon.

UNIT 2 - THE LABRADOR GROUP

The Labrador Group consists of mixed siliciclastic and carbonate sediments with some mafic volcanics at its base. The group unconformably

overlies the Precambrian basement (Unit 1) in the southwest corner of the map area. It outcrops in the area between the Salmon River and Beaver Brook. The group is locally well exposed along the Plum Point Road east of the Main Brook-Roddickton Road.

Four formations in the Labrador Group are recognized in the area.

Subunit 2A - Volcanic rocks

Subunit 2A consists of tholeiitic, predominantly subaerial mafic volcanics (Strong & Williams, 1972; Strong, 1976). The volcanic rocks outcrop locally as outliers upon Precambrian basement (Knight & Saltman, 1980).

Subunit 2B - Bradore Formation

The rocks of subunit 2B occur in the southwestern part of the Roddickton map area. They unconformably overlie the Precambrian basement and are presumed to be earliest Cambrian in age.

They consist of red-brown weathering, immature conglomerates and medium to fine grained, arkosic sandstones which show crossbedding.

The rocks of subunit 2B are not well exposed, because glacial till covers the strata and because the unit weathers easy. Blocks of subunit 2B lithologies are easy to recognize and locally are common in the glacial tills.

Subunit 2C - Forteau Formation

Subunit 2C consists of green-gray, pyritiferous and calcareous siltstones. Minor black to gray shales, mottled pink limestones and some thin sandstones are present. This formation was described in detail by Knight & Saltman (1980).

The subunit is highly fossiliferous and lime nodules and limestone beds contain abundant *Salterella* that give a Lower Cambrian age for the formation.

Subunit 2D - Hawke Bay Formation
equivalents

This subunit, consisting of mixed lithologies of oolitic limestones, mudstones and shales, was described by Knight & Saltman (1980). In the area north of Beaver Brook the lateral equivalent strata are quartzites of the Hawke Bay Formation. South of Beaver Brook the quartzites disappear and pass into subunit 2C.

UNIT 3 - PORT AU PORT GROUP EQUIVALENTS

A Middle to Upper Cambrian (?Lower Ordovician) carbonate sequence named the Port au Port Group elsewhere in western Newfoundland (Knight, 1980b) includes two informal subunits in the map area. The lower subunit consists of limestone and the upper one is predominantly dolostone.

Subunit 3A - (Equivalent to Micrite
Formation of Knight, 1978; and
March Point Formation, Knight, 1980b)

This subunit conformably overlies the Labrador Group. It occurs in a broad belt trending north-northwest from Salmon River Valley east and westward. It consists of black to dark gray, argillaceous micrites, stratified micrites and bioturbated micrites. Lenses of sparry biosparites and oolitic limestones associated with stromatolites are secondary. Fossils have not been recorded in the map area, but Knight & Saltman (1980) reported the presence of trilobites from lateral equivalent limestones, suggesting a late Middle Cambrian age.

Subunit 3B - (Dolomite Formation,
Knight, 1978, 1980a; Petit Jardin
Formation, Knight, 1980b)

Subunit 3B gradationally overlies 3A. Subunit 3B is well exposed along the Main Brook road and the Croque road. It consists mostly of pale gray to dark gray dolostones. Other lithologies include gray to white fine crystalline

dolostones, dark gray to black cherty dolostones and brown gray shales. Stromatolitic mounds and finely laminated light gray dolostones occur at specific horizons. Repetitive sequences consisting of mottled dolostone with minor dolomitic shale and stromatolitic mounds are common. Mudcracks, intraclastic breccias and some ripple marks are present in the sequences.

The dolostones of subunit 3b are nonfossiliferous in the map area. The subunit is correlated lithologically with dolostones of the Petit Jardin Formation elsewhere on the Great Northern Peninsula. The Petit Jardin Formation is dated as Upper Cambrian; it may extend into the Lower Ordovician.

The Petit Jardin Formation is subdivided into four members elsewhere on the Great Northern Peninsula (Knight, 1980a, b). Within the map area subdivision of the dolostones is not possible, as has been noted elsewhere in the Hare Bay and Roddickton areas (Knight & Saltman, 1980; Stouge, 1981). Subunit 3B is also recorded within the parautochthonous sequence (Unit 7) where it outcrops on the Conche Road near the Roddickton Road. Here the dolostones are white, thick bedded and pale yellow weathering. Locally, mudcracks and mudflake breccias are preserved but mostly the subunit is recrystallized.

UNIT 4 - THE ST. GEORGE GROUP

The St. George Group consists of two units in the area (Cooper, 1937). Elsewhere on the Great Northern Peninsula, it has been subdivided into four (Knight, 1978) or three formations (Knight & Saltman, 1980; Stouge, 1981). At this stage, however, it is considered best to separate the St. George Group into two subunits or formations that are broadly the same as the Brent Island Limestone and the Southern Arm Limestone of Cooper (1937). In general, both formations consist of sediments deposited in a transgressive/regressive event and may include a disconformity

CANADA BAY				HARE BAY		SYSTEM				
BETZ 1939	KNIGHT & SALTMAN 1980	COOPER 1937	STOUGE 1981	THIS REPORT	KNIGHT 1980b	BRITAIN SERIES	AMERICAN SERIES	NAAM FORMER COUNTRIES DON'T	ORDOVICIAN	CAMBRIAN
	Goose Tickle Formation	Goose Tickle Slate	Goose Tickle Formation	Goose Tickle Formation	Goose Tickle Formation	LLANVIRN	CHAMPLANIAN		MIDDLE	
Bide Arm Formation	Table Head Formation	Hare Island Limestone	Table Head Formation	Table Head Formation	Table Head Formation			4		
Chimney Arm Formation ∞	Siliceous Dolomite Formation	Southern Arm Limestone	Unit 3D	Southern Arm Formation	Bellburns Formation			2 - 3		
	Catoche Formation Equivalent		Catoche Formation & Equivalents		Catoche Formation			I		
	Unnamed Formation Equivalent	Brent Island Limestone	Boat Harbour Formation & Equivalents		Boat Harbour Formation			E		
	Watts Bight Formation Equivalent		Watts Bight Formation & Equivalents	Brent Island Formation	Watts Bight Formation			D		
(Disconformity)	Dolomite Formation		Subunit 2B	Subunit 3B	Petit Jardin Formation			?C		
Treytown Pond & Clouds Rapids Formation	Micrite Formation Equivalent		Subunit 2A	Subunit 3A	March Point Formation			C		
(Disconformity)	Unit 2D			Subunit 2D	Hawkes Bay Formation			B		
Forteau Formation	Unit 2C			Subunit 2C	Forteau Formation					
Devil's Cove Formation	Unit 2B			Subunit 2B	Bradore Formation					
Cloud				Subunit 2A						

SCHUCHERT & DUNBAR 1934	LOCHMAN 1938	KLUYVER 1975	KNIGHT 1977	KNIGHT 1978	KLAPPA et al. 1980	KNIGHT 1980a
Table Head Series			Table Head Formation	Table Head Formation	(Mainland Sandstone)	Goose Tickle Formation
					Cape Cormorant Formation Black Cove Formation Table Cove Formation Table Point Formation	Table Head Formation
St. George Series		Port au Choix Formation Catoche Formation Barbaçe Point Formation	Siliceous Dolomite Formation Diagenetic Carbonates Laignet Point Member Catoche Formation Watts Bight Formation Unfortunate Cove Formation	Siliceous Dolomite Formation Diagenetic Carbonates Catoche Formation Unnamed Unit Watts Bight Formation Unfortunate Cove Formation	Upper Dolomite Catoche Formation Boat Harbour Formation Watts Bight Formation	ST. GEORGE GROUP Catoche Formation Unnamed Formation Watts Bight Formation
Green Point Series						
March Point Series	Petit Jardin Formation March Point Formation		Dolomite Formation Micrite Formation Hawkes Bay Quartzite Formation Forteau Formation	Dolomite Formation Micrite Formation Hawkes Bay Quartzite Formation Forteau Formation	Petit Jardin Formation March Point Formation	Dolomite Formation Micrite Formation Hawkes Bay Formation
LABRADOR SERIES	Hawkes Bay Formation Forteau Formation Bradore Formation			LABRADOR GROUP		

Table 1: History of stratigraphic nomenclature of the autochthonous Cambrian-Ordovician rocks on the Great Northern Peninsula. Data from Schuchert & Dunbar, 1934; Cooper, 1937; Lochman, 1938; Betz, 1939; Kluyver, 1975; Knight, 1977; 1980a,b; Knight & Saltman, 1980; Klappa, et al., 1980; Stouge, 1981.

near the top of the subunits (Stouge, 1981, 1982).

Subunit 4A - Brent Island Formation
(Equivalent to Watts Bight and
Boat Harbour Formation of Knight,
1978, 1980a)

A good section of the Brent Island Formation is exposed along the shores of Long Island. Other occurrences include the southern part of North Brent Island and northern part of South Brent Island. The unit is locally well exposed along the Main Brook, Croque and Roddickton roads.

This lower subunit of the St. George Group consists of intercalated, dark gray to black crystalline dolostone, pale gray dolostone, large stromatolite and (?) sponge mounds, 1-3 m in diameter and 40-60 cm high, and bioturbated, well bedded, black micrites. Chert is common within these lithologies as irregular shaped bands and nodules. Massive bedded dolostones interbedded with finely laminated dolostones and dolomitic micrites, arranged in repetitive sequences, form the upper part of the subunit. A disconformity expressed as a 'pebble bed' occurs within these dolostones (Stouge, 1981).

Fossils including gastropods, conodonts and some cephalopods are common in the subunit but trilobites are scarce. The conodonts indicate an upper Lower Canadian age (Midcontinent Fauna B-D of Ethington & Clark, 1971) i.e. Lower Ordovician.

Subunit 4B - Southern Arm Formation
(equivalent to Catoche Formation
and Siliceous Dolomites of Knight
(1978) and Catoche Formation and
Unit 3D of Stouge (1981))

The Southern Arm Formation is best exposed along the coast and on the islands in Southern Arm. The base is exposed on North Brent Island and the top is exposed in Little Spring Inlet.

Subunit 5B consists of well, massive and medium bedded, bioturbated micrite commonly with argillaceous stringers. The micrites are succeeded by large stromatolite and sponge(?) mounds (for a preliminary description see Knight & Saltman, 1980; Stouge, 1981; Stevens & James, 1975). The sequence of mounds is stratigraphically succeeded by massive dolostones and cycles of bioturbated micrite, stromatolite and laminated, usually mudcracked dolostone or dolomitic limestone.

Locally, crystalline dolostones replace the upper part of the limestones and form 'pseudobreccias'. The alteration is commonly spatially related to faults.

Trilobites recovered from the lower half of subunit 4B on Brent Island include *Petigurus nero* (Billings) (Stouge, 1981) *Bolbocephalus* n.sp. (=Gen. et sp. indet Poulsen, 1937). *Bathyrina* sp. and *Illeanus* sp. have been recorded along the road to Roddickton (D. Boyce, personal communication, 1981) within the upper half of the subunit 4B. These fauna indicate an Upper Canadian, i.e. Lower Ordovician age, for the limestones. Conodonts include *Oepikodus communis* and *Bergstroemognathus extensus*, which correlate with Midcontinent Fauna E-1 of Ethington & Clark (1971). The same species have been recorded from the upper half of the Catoche Formation at its type section on the west side of the Great Northern Peninsula (Stouge, 1982).

The cyclic top of the St. George Group yielded *Eoneoprioniodus* sp. and it is Whiterockian or Middle Ordovician in age.

UNIT 5 - TABLE HEAD FORMATION (EQUIV-
ALENT TO HARE BAY LIMESTONE OF COOPER,
1937)

In Hare Bay, Cooper (1937) applied the name Hare Bay limestone this unit, which he correlated with the Table Head "Series" of Schuchert & Dunbar (1934).

Subsequent workers referred the strata to the Table Head Formation (Bostock *et al.*, 1976; Knight & Saltman, 1980; Stouge, 1981). Traditionally, the Table Head Formation comprises lower Table Head limestone, middle Table Head limestone and shale, and upper Table Head black shale (Schuchert & Dunbar, 1934). It has more recently been redefined as a group and subdivided into three formations by Klappa *et al.*, (1980).

Generally, lower Table Head limestones are well exposed. Good sections exist in Little Spring Inlet, Big Spring Inlet, Shoal Arm, southeast coasts of Southern Arm and along the shore east of Burnt Village. The lower Table Head limestones consist of massive to medium well bedded, blue-gray to black micrites. The micrites are characterized by argillaceous stringers and bioturbation is common. Fossils including trilobites, cephalopods and gastropods are present in moderate numbers. Black chert is commonly present as nodules or form coherent layers. Locally, as on Road 16, southeast of Salmon River, the limestones contain beds of light gray micritic limestones intercalated with dark gray to brown, hard micrites of middle Table Head affinity.

Middle Table Head consists of nodular bedded, micritic limestones and biosparites separated by brown shale. The shales increase up section and the subunit passes gradationally into the black shales of the upper Table Head; locally the two subunits cannot be readily separated. The middle Table Head is rich in brachiopods, trilobites, cephalopods and very abundant conodonts (Fahraeus, 1970; Stouge, 1980a, b, 1981). The upper Table Head contains graptolites and phosphatic brachiopods.

The middle Table Head and upper Table Head are generally poorly exposed, although complete sequences occur at Little Spring Inlet, Big Spring Inlet and east of Jack Patey's Point. Inland,

sporadic occurrences were noted at Phils Pond and west of the intersection of Plum Point/Main Brook - Roddickton Roads, where the strata are part of a fault breccia.

UNIT 6 - GOOSE TICKLE FORMATION

The Goose Tickle Formation gradationally overlies shales of the Table Head Formation. The formation includes bedded siltstones and shales intercalated with easterly derived sandstones (Cooper, 1937; Stevens, 1970; Tuke, 1968; Smyth, 1973; Stouge, 1981). The sandstones are gray-green, brown or black. They are graded and include complete Bouma sequences (Bouma, 1962) as well as carrying basal sole marks such as flute casts. The formation coarsens upwards and contains conglomeratic layers near the top.

The Goose Tickle Formation is well exposed along the shores of Hare Bay. Inland, the outcrops are mostly covered, but have been exposed in several abandoned quarries seen along Road 16.

Fossils are sparse and only fragmented graptolites have been recorded. North of the map area, Erdtmann (1971a, b) recorded graptolites of Middle Ordovician age.

PARAUTOCHTHONOUS ROCKS

In the map area, parautochthonous rocks occur in a number of thrust slices that trend north-northeast. They are well exposed along the Main Brook road, at White Hump Pond and along the shores in the western part of Coles Pond. The parautochthonous rocks structurally overlie the Table Head Formation (Unit 5) on the Main Brook road. They structurally overlie the St. George Group (Unit 4) at White Hump Pond and the Port au Port Group at Coles Pond. The maximum distance of transport for the thrust slices is interpreted to be 10-14 km judging from the extension of the laterally equivalent autochthonous rocks (see Knight and Saltman, 1980; Stouge, 1981).

Some of the lithologies of the parautochthonous rocks matches with those of the autochthonous rocks, and they were included in the Goose Tickle Formation (Unit 6) by earlier workers (Bostock *et al.*, 1976).

Three lithologies occur within the parautochthonous sequence, namely gray to black shales, bedded oolitic and micritic limestones and dolostones. The rocks are generally highly deformed and are not easy to separate on the map at the scale of 1:50,000. The three lithologies once formed a conformable sequence, and it is likely the bedded limestones at least correlate with Middle Cambrian limestone of subunit 3.

UNIT 7

This map unit begins with a gray to black shale. Typically, it is pyritiferous and it weathers white-gray and is associated with a dark gray to green arkose. Upwards the shales become interbedded with thin bedded limestone, laminated calcareous siltstone and oolitic-oncolitic limestones to form the lower half of map unit 7.

This is then superseded by a middle sequence of thin bedded limestones interbedded with thin siltstone and yellow finely laminated dolostone beds. This is, in turn, overlain by massive bedded oolitic limestone, oncolitic stromatolites and oncolite beds. This sequence most probably correlates with Subunit 3A or the March Point Formation of the Port au Port Group.

Thick bedded dolostones equivalent to the Petit Jardin Formation (Subunit 3B) of the autochthon form the top sequence of the parallochthonous rocks.

THE HARE BAY ALLOCHTHON

The Hare Bay Allochthon forms the northernmost sample of transported rocks in the Newfoundland Appalachians (Stevens, 1970; Smyth, 1973; Williams, 1975). In the map area, the Hare Bay

Allochthon extends from Big Spring Inlet to the east. It trends south-southwest throughout the map area and continues across Canada Bay in the south outside the map area. The Hare Bay Allochthon is about 100 km long and about 40 km across at its widest part. South of Hare Bay, the allochthon is about 40 km long and 20 km across.

The rocks represent a collection of more easterly terrains that once lay at the ancient continental margin of Eastern North America (Stevens, 1970). The maximum distance of transport for the top slices in the Hare Bay Allochthon is estimated at 80 km (Williams and Smyth, 1973). The allochthon is underlain in most places by shaly melange with sedimentary, volcanic, plutonic and locally serpentinite blocks (Unit 8).

The allochthon consists of contrasting rock groups and structural slices which structurally overlie each other (Williams, 1975) (Table 2). The slices, in structural ascending order are: the Northwest Arm Slice, the Maiden Point Slice assemblage, Grandois Slice, Milan Arm melange (Slice), Cape Onion Slice and the St. Anthony Slice assemblage. The lower structural slices (Maiden Point Slice assemblage and the Grandois Slice) consist predominantly of clastic sedimentary rocks. The intermediate Cape Onion Slice of the Hare Bay Allochthon consists mainly of volcanic rocks and some graptoliferous shales. The ophiolite slice or the St. Anthony Slice assemblage overlies all others. It has travelled the farthest west and now lies on autochthonous rocks. A narrow metamorphic aureole, which is attached to the stratigraphic base of the St. Anthony Slice assemblage has been related to obduction and to the beginning of the transportation towards the east (Williams and Smyth, 1973).

In the southern Hare Bay area (Figure 2), the Hare Bay Allochthon comprises the Northwest Arm Slice (Williams, 1975) (Unit 8), the Maiden

HARE BAY ALLOCHTHON

(from Smyth, 1973; Williams, 1975; Bostock, et al., 1976; Smyth, 1980, pers. comm., this report)

GROUP	FORMATION	SLICE ASSEMBLAGE/Slice	LITHOLOGIES	AGES
ST. ANTHONY GROUP	WHITE HILLS Peridotite	ST. ANTHONY SLICE	Harzburgite, dunite and minor pyroxenite	Lower Ordovician
	GREEN RIDGE Amphibolite		Green to black hornblende-plagioclase schist.	
	GOOSE COVE Schist		Polydeformed and metamorphosed sequence of green agglomerate and mafic pillow lavas.	
	IRELAND POINT Volcanics		Agglomerates and mafic pillow lavas	
	Cape Onion Formation		Mafic pillow lava, agglomerate and black graptoliferous shale.	
Milan Arm Melange		Milan Arm Melange	Black and green shaly matrix with blocks of peridotite, volcanic rocks, amphibolites and graywackes.	Lower Ordovician
GRANDOIS GROUP	IRISH Formation	GRANDOIS SLICE	Lime turbidites.	U. Cambrian to L. Ordovician
MAIDEN POINT GROUP	MAIDEN POINT Sandstone	MAIDEN POINT SLICE ASSEMBLAGE CROQUE HEAD SLICE MAIDEN POINT SLICE EPINE CADORET SLICE	Graywacke, quartz-pebble conglomerate, mafic pyroclastic rocks and pillow lava.	Precambrian to Early Cambrian
	MAIDEN POINT Volcanics		Black and gray slates and minor sandstones.	Precambrian to Early Cambrian or Middle Ordovician
	MAIDEN POINT Group or GOOSE TICKLE Formation		Black and bright green shale, buff siltstone, limestone, chert and limestone breccia.	Lower Ordovician
	NORTHWEST ARM Formation	NORTHWEST ARM SLICE		

TABLE 2: Rock units and structural slices within the Hare Bay Allochthon, listed from structurally lowest (bottom) to structurally highest (top) in the allochthon. The units, which are present within the map area, are written in capital letters.

Point Slice assemblage (Williams, 1975) (Units 11, 12,), the Grandois Slice (Unit 13), and the new Epine Cadoret Slice (Unit 9), which structurally underlies the Maiden Point Slice. The Epine Cadoret Slice is separated from the Maiden Point Slice assemblage by a melange (Unit 10). A small part of the St. Anthony Slice assemblage (Unit 14) structurally overlies the Croque Head Slice (Unit 12) (Table 2) of the Maiden Point Slice assemblage south of Croque Head. On Fishot Island east of the map area, a metamorphic aureole occurs at the base of the St. Anthony Slice (Smyth, 1973; Williams and Smyth, 1973; Jamieson, 1977; Jamieson and Strong, 1981). Toward the west, the Hare Bay Allochthon sedimentary rocks are emplaced onto the carbonate platform. In southern Hare Bay, the Maiden Point Slice has been eroded in its central part to expose the autochthonous St. George Group, Table Head and Goose Tickle Formations in a structure named the White Arm Window (Smyth, 1973).

UNIT 8 - NORTHWEST ARM FORMATION AND SLICE

The Northwest Arm Formation (Cooper, 1937) forms a separate slice (Williams, 1975) within the Hare Bay Allochthon. It has a chaotic internal structure. It consists of finely bedded black and bright green shale, which are rich in pyrite. Interbeds of gray and buff weathering sandstones, gray to light brown crossbedded dolostones and hemipelagic limestones, limestone breccia and buff to dark gray to green chert and argillite. Blocks of pillow lava and ophiolitic rocks occur in the unit. The shales form a matrix around the blocks.

According to Williams (1975), the disrupted Northwest Arm Formation should be distinguished from melanges by its lack of volcanic blocks and other exotic blocks. Based on this mapping, the exposures within the map area next to and within the Maiden Point Slice assemblage are melanges. Only at Jack

Patey's Point and Goose Tickle Point are the volcanics apparently missing. Along the shoreline from Shoal Arm to Little Spring Inlet abundant pillow lava blocks occur.

UNIT 9 - EPINE CADORET FORMATION AND SLICE

The name of this at present informal unit is derived from Epine Cadoret, which forms the inner southwestern cove of the Croque Harbour fiord complex. The rocks of Unit 9 are exposed in the inner part of the cove west of Croque and along the road to St. Julien's. The Epine Cadoret formation and slice outcrops extensively on the St. Julien's map area near to and north of the community of Croque.

The rocks consist of fine grained argillite, graywackes and dark gray-brown to black slates. The rocks weather a light gray to white color and the sequence apparently coarsens upwards.

The affinity of the Epine Cadoret rocks is uncertain. The rocks may be allochthonous equivalents of the Goose Tickle flysch (Smyth, 1973) because of the upward coarsening of the unit and its lithic similarity to the Goose Tickle Formation. Alternatively, the clastic sediments may be correlative with the Maiden Point Formation and form the oldest slice of the Maiden Point Slice complex. Presently, no conclusive data are available to resolve the problem and the question is left open.

UNIT 10

Unit 10 is a narrow melange unit that structurally overlies the Epine Cadoret Slice. It is overlain structurally by the Maiden Point Slice. Unit 10 is well exposed along the road to Grandois (St. Julien's).

Unit 10 has a chaotic internal structure. It consists of finely bedded black and bright green shale, which are

rich in pyrite. Large exotic serpentine blocks (10 x 20 m) characterize this unit.

UNITS 11-12 - MAIDEN POINT FORMATION AND SLICE ASSEMBLAGE

The Maiden Point Formation (Tuke, 1968, formerly Maiden Point Sandstone of Cooper, 1937), occurs in several structural slices collectively referred to as the Maiden Point Slice assemblage. In the map area, the Maiden Point Slice (Unit 11) is separated by a melange from the structural superimposed Croque Slice (Unit 12) (Smyth, 1973). Both contain rocks of the Maiden Point Formation.

The Maiden Point Formation includes a lower sequence of volcanic rocks overlain by a more prominent sequence of monotonous graywackes, sandstones, shales and quartz-pebble conglomerates.

Subunit 11A - Maiden Point volcanic rocks

The volcanic rocks within the map area outcrop in a continuous belt from Great Islets Harbour in the north to Croque Harbour in the south. Outcrops of volcanic rocks also occur along the western margin of the allochthon at Coles Pond and toward the Croque road in the north.

Dark green, massive basalts account for the bulk of the exposed volcanic rocks. Felsic volcanics containing secondary amphibole and epidote, outcrop 2 km north-northwest of Grandois. Altered mafic agglomerates and tuffs are commonly present.

The volcanic rocks of the Maiden Point are interpreted to be related with rifting (Smyth, 1973) and opening of the proto-Atlantic ocean (Williams & Stevens, 1974). Jamieson (1977) provided data that suggested the volcanics had been subjected to high pressures during obduction of the Hare Bay allochthon.

Subunit 11B - Maiden Point sandstones

The sequence comprises coarse gray lithic sandstones, quartz-pebble conglomerates, gray sandstone and interbeds of siltstone and shale. The sandstone is gray to white and typically weathers to a rusty brown color. The rocks are moderately sorted, locally conglomeratic, and contain graded beds. Clasts within conglomeratic horizons consist almost entirely of white and blue quartz.

The blue quartz, granite and metamorphic rock fragments in the Maiden Point sandstones indicate a source to the west in Grenvillian rocks of the Long Range Mountains. This is supported by the finer grained lithologies found towards the east within more distal parts of the westerly derived sequence.

UNIT 13 - GRANDOIS GROUP AND SLICE

Unit 13 is well exposed on St. Julien Island and belongs to the Grandois Group. It consists of minor brecciated sandstones overlain by siliceous limestone and shales. The upper part of the formation is developed as sandy limestone. The limestones were named the Irish Limestone by Smyth (1973). They were included with adjacent conglomerates of the St. Julien Island Formation in the Grandois Group by Williams (1975). However, Smyth (personal communication, 1981) now believes, by comparison to rocks in the Sops Arm area, that the St. Julien Island Formation may be Silurian in age. Only the Irish Formation is thus assigned to the group.

The age of the limestones is unknown. It is possible, however, that they correlate with the Cooks Brook Formation (Stevens, 1970) of the Humber Arm Supergroup in the south (Smyth, 1973). This correlation would suggest a late Cambrian age.

UNIT 14 - GOOSE COVE SCHIST AND GREEN
RIDGE AMPHIBOLITE OF THE ST. ANTHONY
GROUP AND SLICE ASSEMBLAGE

The St. Anthony Group includes the Ireland Point volcanics, Goose Cove schist, Green Ridge amphibolite and White Hills peridotite. It outcrops predominantly in the area north of Hare Bay where it has been well described and studied by several workers (Tuke, 1968; Smyth, 1973; Malpas, Stevens and Strong, 1973; Williams and Smyth, 1973; Williams, 1975; Jamieson and Strong, 1981) and warrants no further documentation here.

In the map area the St. Anthony Slice overlies the Croque Head Slice (Unit 12) of the Maiden Point Slice assemblage at Croque Head and the Maiden Point Slice (Unit 11) at Fishot Islands. The structural base of the St. Anthony Slice in the map area coincides with the Goose Cove schist.

The Goose Cove schist consists of polydeformed and metamorphosed green tuff, agglomerate and mafic pillow lava. Minor graywackes, black slates and marbles also occur. The rocks are metamorphosed to greenschist and epidote amphibolite grade.

The Green Ridge amphibolite consists mostly of green to black hornblende-plagioclase schists that were derived from mafic volcanic rocks. They range from hornblende granulite to amphibolite facies.

UNIT 15 - ST. JULIEN ISLAND FORMATION

Unit 15 outcrops on the eastern half of St. Julien Island where it is faulted against the Grandois Group (Unit 13). The formation is possibly Silurian in age (Smyth, personal communication, 1981).

The formation consists of approximately 60 m of polymictic conglomerate and interbedded red to green and purple graywacke. Red

quartzite, vein quartz, acid volcanic rocks and granite form the clasts in the conglomerates.

UNIT 16 - CARBONIFEROUS SEDIMENTARY
ROCKS

Gently folded Carboniferous sedimentary rocks are well exposed on the Cape Rouge Peninsula and Conche Peninsula. The sedimentary rocks are divided into two formations: the Crouse Harbour and the Cape Rouge Formations (Bostock *et al.*, 1976). The Crouse Harbour Formation consists of gray to lesser brown-red conglomerate, some sandstone, thinly bedded gray mudstones and minor dolomite. The Cape Rouge Formation consists of gray to brown sandstones, siltstones and mudstones. Dolomite beds also occur. Plant fossils preserved in the siltstones indicate a Mississippian age for the formation.

STRUCTURAL GEOLOGY

The autochthonous carbonate sequence is gently folded in the west and cut by several high-angle faults. The rocks display increasing structural complexity eastward where they are tightly folded and imbricated along a series of northeast-trending thrust faults. The rocks are locally sheared and metamorphosed to marble, particularly within the White Arm Window and along the western edge of the Maiden Point Slice assemblage.

Three deformational events are recognizable in the map area. The first deformation (D_1) largely confined to the transported rocks, is related to assembly and emplacement of the Hare Bay allochthon. Second generation structures (D_2) fold and displace D_1 features and are, in turn, offset by faults of D_3 age.

The earliest recognizable deformation D_1 is confined to transported rocks of the Maiden Point and Epine Cadoret slices, and to melange zones at the interface between the

autochthon and allochthon (Northwest Arm Formation). The uppermost part of the autochthonous sequence (*i.e.* the Goose Tickle Formation) also contains structures correlative with the D_1 event, and moreover, appears to form the melange matrix near Jack Patey's Point.

D_1 deformation is characterized by west verging tight to isoclinal mesoscopic folds. The folds are parallel and asymmetric, have southeast dipping axial planes and variably plunging axes. Penetrative slaty cleavage, oriented axial planar to the isoclinal folds, is well developed in pelitic rocks of the transported sequence, the melange zone and the autochthonous Goose Tickle Formation. Beds of competent limestone and sandstone within and proximal to the melange zones commonly exhibit bedding parallel to extensional features (pinch and swell structure and boudinage). D_1 structures reflect the high strains attendant with assembly and emplacement of the allochthon.

D_1 structures are folded about macroscopic D_2 fold axes. The D_2 folds are consistently west verging, but display considerable variation in geometry from west to east across the map area. The folds are gently open and upright in the western and central parts of the Salmon River area. Wavelengths decrease and amplitudes increase toward the east, where the folds have tighter closures and are locally overturned toward the west. Cleavage axial planar to the folds (S_2) is most prominent in the east, but is nowhere pervasive. Overturned limbs of the F_2 folds are commonly sheared out and define a series of low angle thrusts directed toward the northwest. Imbrication is most intense in the eastern part of the area, as seen at Coles Pond where autochthonous and allochthonous rocks are juxtaposed and repeated along a complex series of faults.

D_1 and D_2 structures are displaced by a series of dominantly northeast trending high angle faults (D_3). The

faults are generally more numerous in the east, but remain a prominent feature in the gently folded terrain of the Salmon River and Eddies Cove West map areas. The fault zones are marked by steeply dipping joint systems parallel to the plane of displacement. The jointing surfaces are commonly spaced as little as 10-30 cm apart at the fault plane; the spacing gradually increases away from either side of the fault. Vein quartz is typically associated with the D_3 faults, particularly in the eastern, more deformed portion of the map area.

WHITE ARM WINDOW

From White Arm Pond and toward the south, the Maiden Point Slice has been eroded to expose the White Arm Window (Smyth, 1973) (Figure 2).

The White Arm Window includes the Brent Island and Southern Arm Formations of the St. George Group, the Table Head Formation and the Goose Tickle Formation. The sequence is, however, structurally dissected by faults and strongly cleaved (both trending northeast). No continuous section passing from Lower to Middle Ordovician occurs within the window.

Where preserved, the lithologies do not differ from the units of the St. George Group, the Table Head Formation and the Goose Tickle Formation as seen elsewhere toward the west. Locally, the limestones/ dolostones are transformed into white and brown marble. Ghost bedding, however, can be recognized and supports the subdivision suggested here (Figure 1). The Goose Tickle Formation is transformed locally to either a disrupted unit or to a gray slate.

MINERALIZATION

Mineral occurrences within the map area were reported by Knight & Saltman (1980), Knight (1980a) and Stouge (1981). Within the St. George Group, the Zn-bearing horizons occur both in the Brent Island and the Southern Arm

Formations. Minor Zn showings have also been noted within Cambrian dolostones of Unit 3 north of Ocean Pond (Figure 1). The St. George Group mineralization is located in secondary dolomitized dolostones and limestones ("Pseudobreccia"). The Cambrian mineralization occurs in tectonically brecciated zones and as small occurrences in the dolostones. The "pseudobreccia" and mineralization are distributed in northeast-southwest trending zones, some of which have a spatial relationship to D_3 fault trends in the central part of the Salmon River map area.

It appears also that structurally controlled vertical zones of metallic mineralization exist west of Salmon River. Mineralization occurs in the rocks below the main host beds as scattered, small, structurally controlled occurrences in the underlying Cambrian-Lower Ordovician units. With more information on the detailed structure of the Lower Ordovician, it may be shown that geometry of the structures is important for the location of mineralization (*e.g.*, tectonic brecciation occurs along the hinges of the folds; disseminated sphalerite mineralization in breccia occurs parallel to the axes of the folds). Also, the northeast-trending, D_3 fault planes apparently served as conduits for the influx of fluids which caused the extensive replacement of the carbonate host rocks.

The sphalerite mineralization may well be multileveled, and not stratigraphically bound. It was probably attenuated by the chemical unsuitability of certain stratigraphic units as host rocks. Generally, deeper (vertical) exploration beneath known ore bodies may be more effective than continuing shallow (lateral) exploration techniques.

Near the western boundary of the White Arm Window, chalcocite and malachite are associated with very minor galena and sphalerite. The mineral-

ization occurs as disseminations in white quartz veins up to 20-45 cm wide, which cut light brown-yellow recrystallized dolostones. The quartz veins are typically associated with the D_3 faults. Stratigraphically, the mineralization occurs in the upper part of the Southern Arm Formation of the St. George Group. Similar setting and associated quartz veins proximal to faults occur in the eastern part of the window. No mineralization was discovered in these areas.

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THE CAMBRIAN-ORDOVICIAN BOUNDARY
AND THE POSSIBLE CHOICE OF THE STRATOTYPE IN NEWFOUNDLAND

by

R.K. Stevens⁺ and S. Stouge

INTRODUCTION

In the summer of 1981, the authors participated in a field trip arranged by the International Union of Geological Sciences Working Group on the Cambrian-Ordovician Boundary. The excursion took place in the Gros Morne National Park, where sections of the Cow Head Group (Figure 1) were inspected. The group included Drs. B.F. Norford* (Canada Chairman), R. Ludvigsen (Canada), B.D. Erdtmann* (W. Germany), A.W.A. Rushton* (United Kingdom), J.F. Miller* (U.S.A.), C.H. Kindle (U.S.A.) and J. Shergold* (Australia). Dr. R.F. Fortey (United Kingdom) guided the trip and was assisted by R.K. Stevens. The I.U.G.S. Working Group will visit as many exposures as possible around the world, of the Cambrian-Ordovician transition, in order to make a formal decision with regard to boundary level and stratotype. On this trip, interest was centered on the graptolites, trilobites and conodonts of the Cow Head Group.

THE CAMBRIAN-ORDOVICIAN BOUNDARY
STRATOTYPE

The boundary stratotype should be practical so that a world-wide correlation of different successions in other regions with the stratotype is feasible. Requirements for a boundary-stratotype section include the following:

(1) It should be a continuous and nondisturbed sequence; (2) it should be fossiliferous comprising both shelly and graptolitic facies; (3) the sequence should preferably consist of successively alternating facies rather than a

sequence of uniform facies; and (4) the section should be easily accessible. Other qualities evaluated include political and tectonic stability of the area and the ownership of the land/coastline on which the section is located.

The Cambrian and Ordovician Systems were established in Wales by the pioneers A. Sedgwick, R.I. Murchisoni, C. Lapworth and H. Hicks. It has, therefore, been considered appropriate, mainly based on grounds of historical priority (Whittington & Williams, 1964) to define the Cambrian-Ordovician boundary in Britain. Traditionally, many British scientists placed the Cambrian-Ordovician boundary at the base of Arenigian. In Scandinavia, however, the boundary is placed at the base of Tremadocian or at the first appearance of *Dictyonema flabelliforme* (Moberg, 1900). A third possibility would be to place the boundary within the Tremadocian, at or near the base of Upper Tremadocian (Henningsmoen, 1972).

Of the three possible horizons, the most widely used is that at the base of Tremadoc Series.

The casual reader may ask "Why is the selection of the stratotype important? Does it really matter if a boundary is put here or a few metres over there?". There are two main reasons. In this Province, we understand the importance of agreement on geographic boundaries, both onshore and offshore. If there is no agreement, much energy and money is wasted on fruitless arguments. It is the same in stratigraphy. Secondly, there must be agreement on the correlation of zones

⁺ Dept. of Geology, Memorial University of Newfoundland
^{*} Indicates Working Group Members

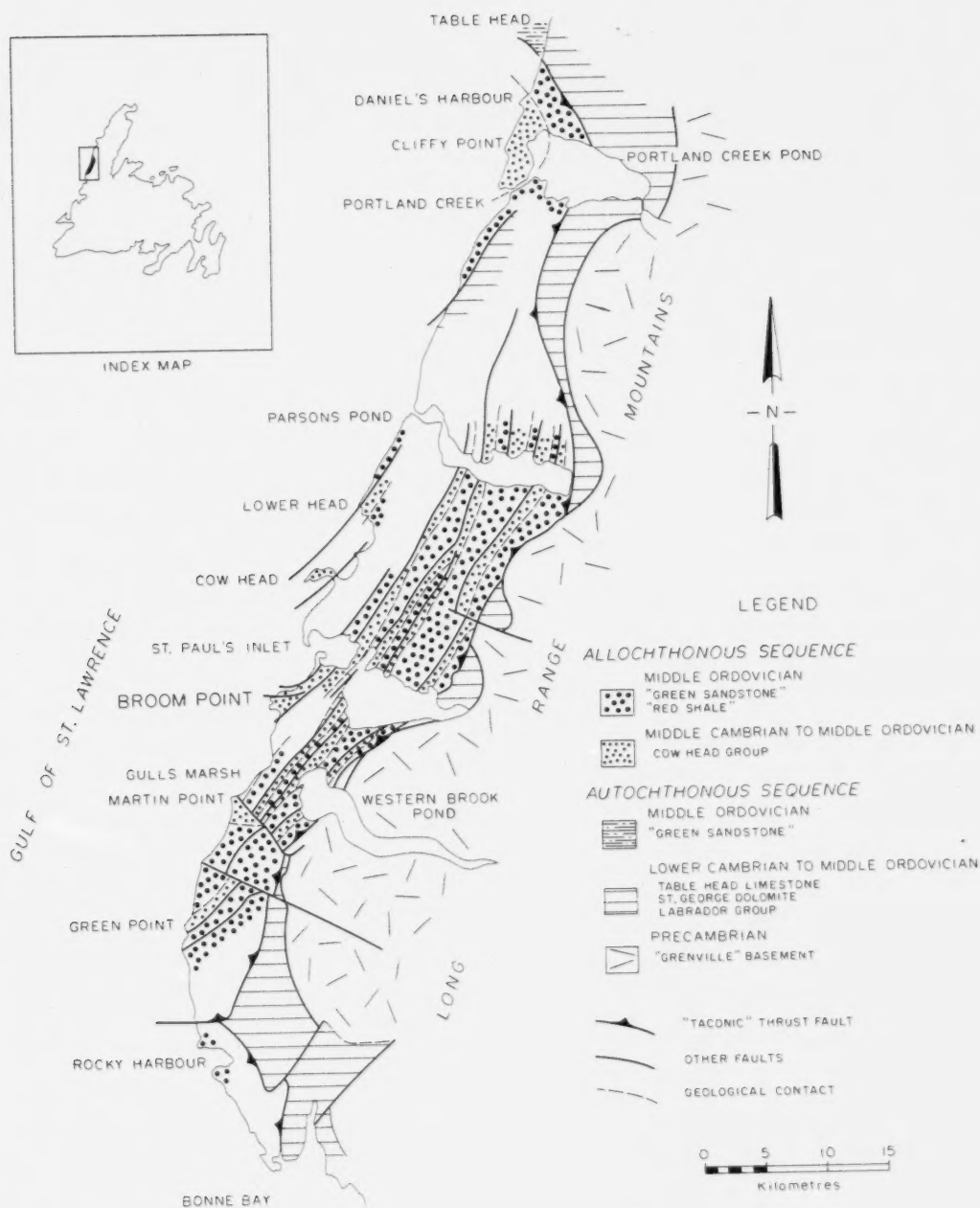


Figure 1. Geologic map of the Cow Head Region. Geology modified from Oxley (Hubert *et. al.* 1977).

based on different taxa such as graptolites, trilobites and conodonts. Calibration points are needed if fine correlation between continents and fauna provinces within the continents is to be attained. The advantage of precise correlation should be obvious.

The major problem in fixing the Cambrian-Ordovician boundary with the subsequent choice of a suitable type section appears to be the position of the Tremadocian. The base of the Tremadoc Series has yet to be formally defined in a stratigraphic section. Stubblefield (1956) proposed a section in Wales where the Cambrian-Ordovician transition is preserved. Because the fossils are not abundantly represented or well preserved, strata in Wales have not generally been accepted as boundary stratotype. Furthermore, the sections in Wales are mainly of deep water facies.

In the United States, sequences spanning the Cambrian-Ordovician are developed in platform facies. Most studies there are concentrating on the Trempealeauan-Missisquoi Zones. The correlation over platform facies is good for shelly fauna elements, and conodonts provide good correlation to platform areas outside North America such as Siberia and Australia.

The correlation between the shelly faunas of the shallow and warm water platforms of U.S.A., Siberia and Australia with the graptolitiferous deep and colder water facies such as those from Wales is virtually impossible and correlation is at best tenuous (Table 1). This is due to faunal provincialism that persisted during this time interval. Thus, the platform sequences of North America have not yielded *Dictyonema flabelliforme* and the recognition of the Cambrian-Ordovician boundary based on graptolites is not possible on direct evidence there.

In Canada, the Cambrian-Ordovician boundary transition is best known from marginal areas to the Canadian Shield.

The critical outcrops are preserved in the Cordilleran (west), the Franklinian (north) and the Appalachian (east) orogens (Norford, 1981). The shield formed a stable craton during the Late Cambrian-Early Ordovician time. The craton was fringed by wide carbonate platforms; offshore ocean basins were sites of shale deposition.

The intermediate zones, the deep water slopes of the carbonate platforms and adjacent basin floors were sites of mixed deposition. Coarse and fine carbonate debris were swept from the platform and deposited in deep water. A pelagic rain of fine carbonate was episodically put into suspension on the platform and transported out to sea to settle on the slope with ferruginous silts and clays. The resulting strata are interbedded coarse breccia and conglomerate beds, lime sand turbidites and conglomerate beds, limes and turbidites, pelagic slope mudstones and shales. Just as the sediments are mixed, containing shallow-water platform components and deep water deposits, so the fossils are mixed and elements of both the North American craton succession and the traditional British deep water forms occur interbedded.

In Newfoundland, two localities have been proposed for a stratotype, both of which fulfill many of the requirements outlined above. The first is at Broom Point, western Newfoundland (Fortey & Skevington, 1980) (Figure 1), and the second is on Random Island, eastern Newfoundland (Poulsen, 1976) (Figure 2).

WESTERN NEWFOUNDLAND - BROOM POINT (FIGURE 1)

At Broom Point, limestones, shales and breccias of the Cow Head Group are exposed. The paleontological significance of the Cow Head Group was realized as soon as it was discovered by Richardson (in Logan, 1863) but useful faunal lists were not available until 1958 for graptolites and trilobites

NORTH AMERICA					EUROPE (SCANDINAVIA)				
SYSTEM	SERIES	STAGE	TRILOBITE ZONES	CONODONT ZONES	CONODONT ZONES	TRILOBITE ZONES	GRAPTOLITE ZONES	SERIES	SYSTEM
O R D O V I C I A N	CANADIAN		<i>Symphysurina</i>	<i>Missisquoiia</i>	MIDCONTINENT FAUNA B	<i>Cordylodus angulatus</i> ?	(<i>Clonograptus</i>) <i>Dictyonema flabelliforme</i>	LOWER T R E M A D O C I A N	O R D O V I C I A N
					<i>Cordylodus proavus</i>	<i>Peltocare</i> <i>Boeckaspis</i> <i>Juivyaspis</i> <i>Boeckaspis</i>			
C A M B R I A N	CROIXIAN	TREMPEALEUAN	<i>Saukia</i>		<i>Præconodontus</i>	NOT ZONED	(<i>Radiograptus</i>)	UPPER O S E R I E S O L E N I E S	C A M B R I A N

TABLE 1: Nomenclature of North American and European divisions. Correlation of Cambrian-Ordovician boundary between North America and Europe is not possible. The location of the Cambrian-Ordovician boundary in Europe follows that of Fortey & Skevington (1980) and in North America that of Erdtmann & Miller (1981). Data from Landing, et al., (1978), Henningsmoen (1972) and Erdtmann & Miller (1981).

(Kindle & Whittington, 1958) and 1978 for conodonts (Fahraeus & Nowlan, 1978). Since then additional data has been provided by Erdtmann (1971), Whittington (1963) and Fortey and Skevington (1980). The Working Group also had access to considerable unpublished data collected by N. James, R. Stevens, R. Fortey and E. Landing. These included detailed stratigraphic sections at a scale of 1:100.

Lithologically, the Cow Head Group consists of interbedded calcareous rocks of all grain sizes (micrometres to hundreds of metres) and shales with various carbonate content. Deposition mechanisms of the rocks represent a wide spectrum from debris flows, through turbidity currents and contour currents to pelagic rains. Considerable erosion often took place at the base of some of the coarser beds.

Major breccia horizons can be traced throughout the area (Hubert *et al.*, 1977; James *et al.*, 1979). The coarseness and thickness of the breccia beds or megabreccias decrease from the northwest (*i.e.* Stearing Islands and Lower Head) to the south and east (Green Point and Western Brook Pond). The megabreccias are considered to have been deposited during eustatic lows or regressions (James *et al.*, 1979; Stouge, 1980) that periodically occurred during Cambrian-Ordovician time.

The age of the Group is from Late Cambrian to latest Arenig or earliest Llanvirn. The Group is only 300 m thick at Cow Head, and hence, it is a condensed sequence. Therefore, collecting must be done at closely spaced intervals or whole zones may be missed.

The Cow Head Fauna has four major elements:

- (1) Transported fossils contained in clasts of shallow water limestone of several different facies, representing a plexus of bank faunas.

- (2) Transported slope faunas.
- (3) Indigenous slope faunas.
- (4) Pelagic faunas.

It is clear then that a single section of the Cow Head Group allows correlation between several faunal provinces using a variety of taxa. Strangely enough, correlation between Australia and Newfoundland can be established with all post-early Tremadoc pelagic faunas. In contrast, these faunas differ from the classic areas of Europe. Fortunately, the opposite is true during the Lower Tremadoc so that the Cambrian-Tremadoc boundary, as defined in Europe, can be recognized in several sections in the Cow Head Group using graptolites.

Not all sections are equally useful, however. The best shallow water faunas occur in the coarse northwestern facies. Indeed, it is these that have made Cow Head famous because they contain bank edge genera (*e.g.* Whittington, 1963) which are not commonly preserved in the presently exposed banks of the North American craton. As a rule, the coarsest breccias cut deep into the underlying stratigraphy and, in extreme cases may cut into the underlying breccia beds so that the resultant faunas are of mixed ages. The age of the underlying beds is of little use in determining the age of breccia formation and the pelagic sequence is incomplete. The problem is compounded because sea level change seems to have been particularly pronounced during late Cambrian and Tremadoc times so that breccia generation peaked about then.

In the more distal sections, pelagic sequences are more or less complete judging from the graptolite faunas. The breccias are so thin that there is very little if any erosion beneath them. It is very difficult, however, to extract or find trilobites from both the finer breccias and the interbeds. Only three or four trilobites have been collected, for example, from the Green Point section.

Fortunately, intermediate outcrops at Broom Point combine the best of both the distal and proximal sections. The pelagic sequence is well preserved, the breccias are fossiliferous as are the interbedded limestones.

BROOM POINT SECTION

The following description of the Broom Point Section is based on Fortey and Skevington (1980) and personal communication from Fortey (1981).

Sections through the Cambrian-Ordovician boundary are exposed at two places around Broom Point (see Fortey & Skevington, 1980, Figure 1 for location). Here they are referred to informally as Broom Point north and Broom Point south. Both have yielded excellent faunas through the critical interval.

Graptolites are abundant in the shales; conodonts and "autochthonous" trilobites are recorded from the interbedded limestones and trilobites and conodonts were obtained from clasts in the breccias.

The graptolite record is particularly clear. Rooted dendroids of Cambrian aspect occur with Cambrian trilobites and conodonts. A peculiar radiating form, *Radiograptus*, is the first siculate species and is followed by early Tremadoc members of the *Dictyonema flabelliforme* plexus accompanied by typical early Tremadoc conodonts and trilobites.

The Broom Point south section is complicated by slight erosion at the end of the *Proconodontus* conodont zone and the end of the *Saukia* trilobite zone. This coincides with the Cambrian-Ordovician boundary of most North American workers (Erdtmann & Miller, 1981) but is below the *Dictyonema flabelliforme* fauna and, therefore, according to Europe usage, within the Cambrian. All points considered, the

group felt that the Broom Point north section is the better of the two.

EASTERN NEWFOUNDLAND - RANDOM ISLAND (FIGURE 2)

On Random Island a 1500 m thick Cambrian-Ordovician section was only mildly disturbed during the Acadian Orogeny. The sediments consist of uniformly bedded black shale with siltstones, without any lithological breaks, and represent deep-water deposition. The fossils are predominantly trilobites (Poulsen, 1976; Poulsen & Anderson, 1975), and acritarchs (Martin & Dean, 1981), which indicate a complete transition from

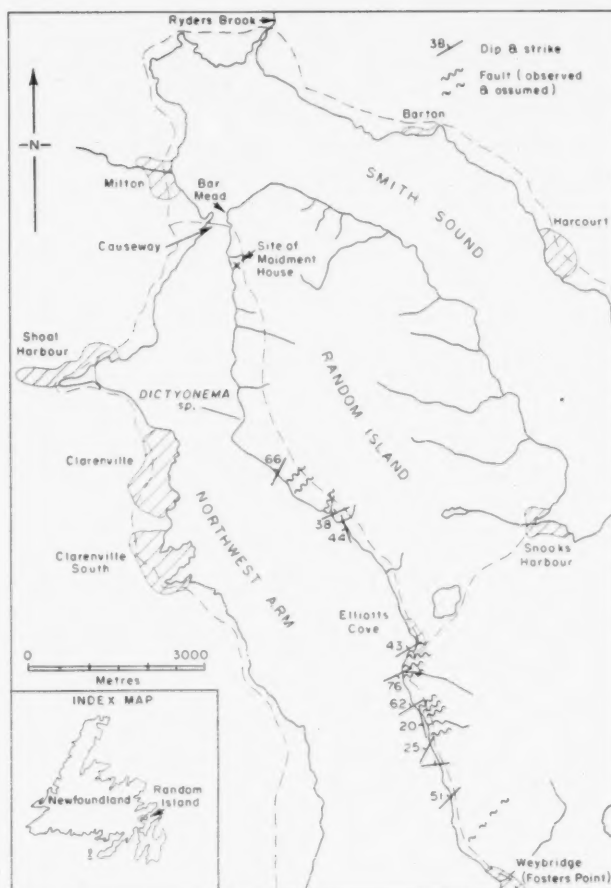


Figure 2. Location map of northwestern of Random Island and adjacent mainland (modified from Martin & Dean, 1980).

Upper Cambrian into the Tremadocian. The presence of a *Dictyonema* of the *D. flabelliforme* type hints at the occurrence of Lower Tremadoc. Work on the Random Island section is still in a preliminary state and the Upper Tremadocian and basal Arenigian are poorly known.

SUMMARY

The decision of the location of the Cambrian-Ordovician boundary stratotype is still undecided. In Newfoundland, the Cambrian-Ordovician transition has been recognized and described from Broom Point in the Cow Head region, western Newfoundland and from Random Island, eastern Newfoundland. Both localities are excellently exposed and fossiliferous, and hence provide the basis for a choice of a stratotype for the Cambrian-Ordovician boundary in Newfoundland. Presently, little detailed work has been carried out on the Random Island Section. Trilobites, acritarchs and graptolites are known, but graptolites are rare. In contrast, the intensive study over the years on the Cow Head Group culminated in 1981 with the visit of the International Union of Geological Sciences Working Group on the Cambrian-Ordovician Boundary. The Broom Point Section allows for the integration of zonal schemes based on graptolites, trilobites and conodonts - even across faunal provinces, and all agreed that the Broom Point north section of the Cow Head Group, western Newfoundland was an excellent contender for the honor of being the world stratotype of the Cambrian-Ordovician boundary.

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GEOLOGY OF THE MIGUELS LAKE MAP AREA (2D/12),

NEWFOUNDLAND

by

S.P. Colman-Sadd and H.A.J. Russell

INTRODUCTION

Preliminary mapping of the Miguels Lake area (Figure 1) at a scale of 1:50,000 was completed during 1981 (Colman-Sadd and Russell, 1981). Further work still needs to be done on the geology of the Devonian or younger subaerial volcanic rocks around Stony Lake in order to give the map uniform quality.

Access is from the Bay d'Espoir - Harbour Breton Highway which runs along the eastern edge of the area. A system of woods roads extends from the highway in the Grand Falls area (2D/13) almost to the west edge of the Miguels Lake area. Most of the roads shown on the NTS 1:50,000 maps are passable in a four-wheel drive vehicle. The northwest corner of the area can be reached from the woods road system that runs west and south from Grand Falls.

Previous work dates back to 1875 when Howley ascended the Northwest Gander River and made the first description of the Great Bend ultramafic rocks (Murray and Howley, 1881). In the early 1950's, exploration by the Buchans Mining Company (Swanson, 1952-1960) resulted in a report on the eastern part of the area by LeComte (1953), and a report and M.Sc. thesis on the western part by Peters (1953). At the same time, the Geological Survey of Newfoundland sponsored work by Grady (1953) on the southern part of the Gander River ultramafic belt, including the Great Bend complex on the Northwest Gander River. Nalco followed up Grady's work with exploration for chromite, asbestos and magnesite (Harrison, 1953; Coleman, 1954). Mapping by the Geological Survey of Canada at a scale of 1:250,000 was

published in 1970 (Anderson and Williams, 1970). The Newfoundland Department of Mines and Energy has since conducted an assessment of the Great Bend ultramafic complex (Kean, 1974) and a regional lake sediment geochemistry survey (Butler and Davenport, 1978). Some of the samples collected by Kean were used in a study of the detailed mineralogy of the ultramafic rocks (Malpas and Strong, 1975). The sedimentology and petrology of the probable Silurian sediments around Great Rattling Brook have been studied by Wessel (1975). Recent industry exploration has been done by Amoco on the Devonian or younger volcanic rocks (Donovan, 1978), Minorex on the ultramafic rocks in the west of the area (Durocher, 1978) and Hudson Bay Oil and Gas on the mafic volcanic rocks of Unit 7 (Dean, 1977a; Lassila, 1979a, b, c, d).

The Miguels Lake area is cut by a major fault zone extending from the northeast tip of the Pipestone Pond ultramafic complex at Atlantic Lake through Miguels Lake in the east. The zone is marked by fault blocks of ophiolitic and Ordovician and Silurian sedimentary rocks. A similar fault zone, associated with the Great Bend ultramafic complex, occurs in the southeast of the area, and the two faults are linked, by way of the Coy Pond and Pipestone Pond Complexes, to form parts of an elliptical ophiolite belt (Figure 2).

Fossiliferous Lower to Middle Ordovician turbidites (2 and 3) occur south of the Atlantic Lake - Miguels Lake fault. Metamorphism in these sediments varies from greenschist to upper amphibolite facies (2 and 3). A

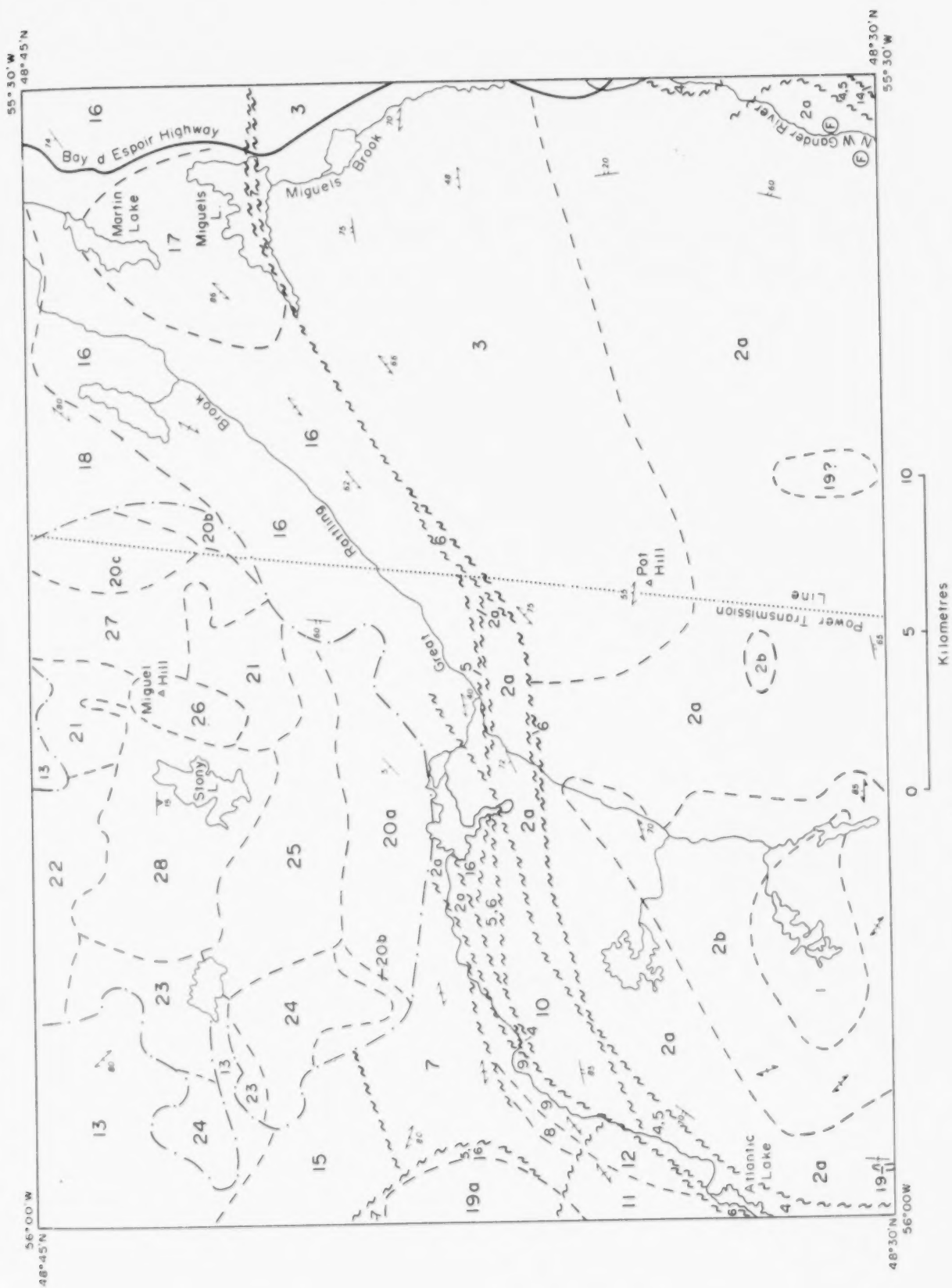


Figure 1. Geological sketch map of the Miguels Lake Area

LEGEND

DEVONIAN OR YOUNGER

- 28 Dark gray to black feldsparphyric rhyodacite: Mainly pyroclastic, locally flow banded.
- 27 Dark gray to dark green feldsparphyric rhyodacitic lapilli tuff.
- 26 Gray and purple flow banded or brecciated rhyolite.
- 25 Purple and pink rhyolite: Mainly pyroclastic, locally flow banded.
- 24 Light purple, feldsparphyric rhyolite: Mainly pyroclastic, locally flow banded.
- 23 Gray rhyolite: Mainly lapilli tuff, locally flow banded.
- 22 Medium grained quartz and feldspar rhyolitic crystal tuff.
- 21 Mainly buff, but locally green and purple, feldsparphyric, pyritiferous rhyolite: Mainly flow banded, but locally pyroclastic.
- 20 Siltstone and sandstone: 20a, gray; 20b, red; 20c, gray and red with blocks of flow banded rhyolite and pyroclastic rocks.

DEVONIAN

- 19 Garnetiferous biotite/muscovite granite; 19a, Overflow Pond Granite.

SILURIAN

- 18 Botwood Group: Wigwam Formation: Red sandstone and siltstone.

UPPER ORDOVICIAN AND SILURIAN

- 17 Interbedded gray sandstone and siltstone and red siltstone.
- 16 Green-gray siltstone with minor sandstone beds.
- 15 Rogerson Lake Conglomerate: Unexposed, extrapolated from outcrop in Noel Paul's Brook area.

MIDDLE ORDOVICIAN AND OLDER - OUTSIDE AND INCLUDING THE OPHIOLITE BELT

Victoria Lake - Baie d'Espoir Groups

- 14 North Steady Pond Formation: Unexposed, extrapolated from outcrop in Burnt Hill area.
- 13 Tally Pond Formation: Interbedded felsic crystal tuff and lapilli tuff.
- 12 Felsic crystal tuff.
- 11 Semipelitic schist
- 10 Salmon River Dam Formation(?): Interbedded purple-gray sandstone, siltstone and minor shale.

Pipestone Pond - Great Bend Complexes, etc.

- 9 Black shale interbedded with fine grained sandstone.
- 8 Conglomerate: Composed mainly of mafic volcanic clasts.
- 7 Mafic pillow lava, breccia and tuff.
- 6 Gabbro, with minor trondhjemite.
- 5 Pyroxenite.
- 4 Peridotite.

MIDDLE ORDOVICIAN AND OLDER - INSIDE THE OPHIOLITE BELT

- 3 Green-gray siltstone and sandstone.
- 2 2a, Interbedded gray sandstone, siltstone and shale with minor conglomerate and limestone beds, metamorphosed in the greenschist and amphibolite facies; 2b, migmatite and granitoid gneiss thought to be derived from 2a.
- 1 Interbanded, migmatized, granitic, amphibolitic, semipelitic and psammitic gneisses

Eutaxitic foliation /

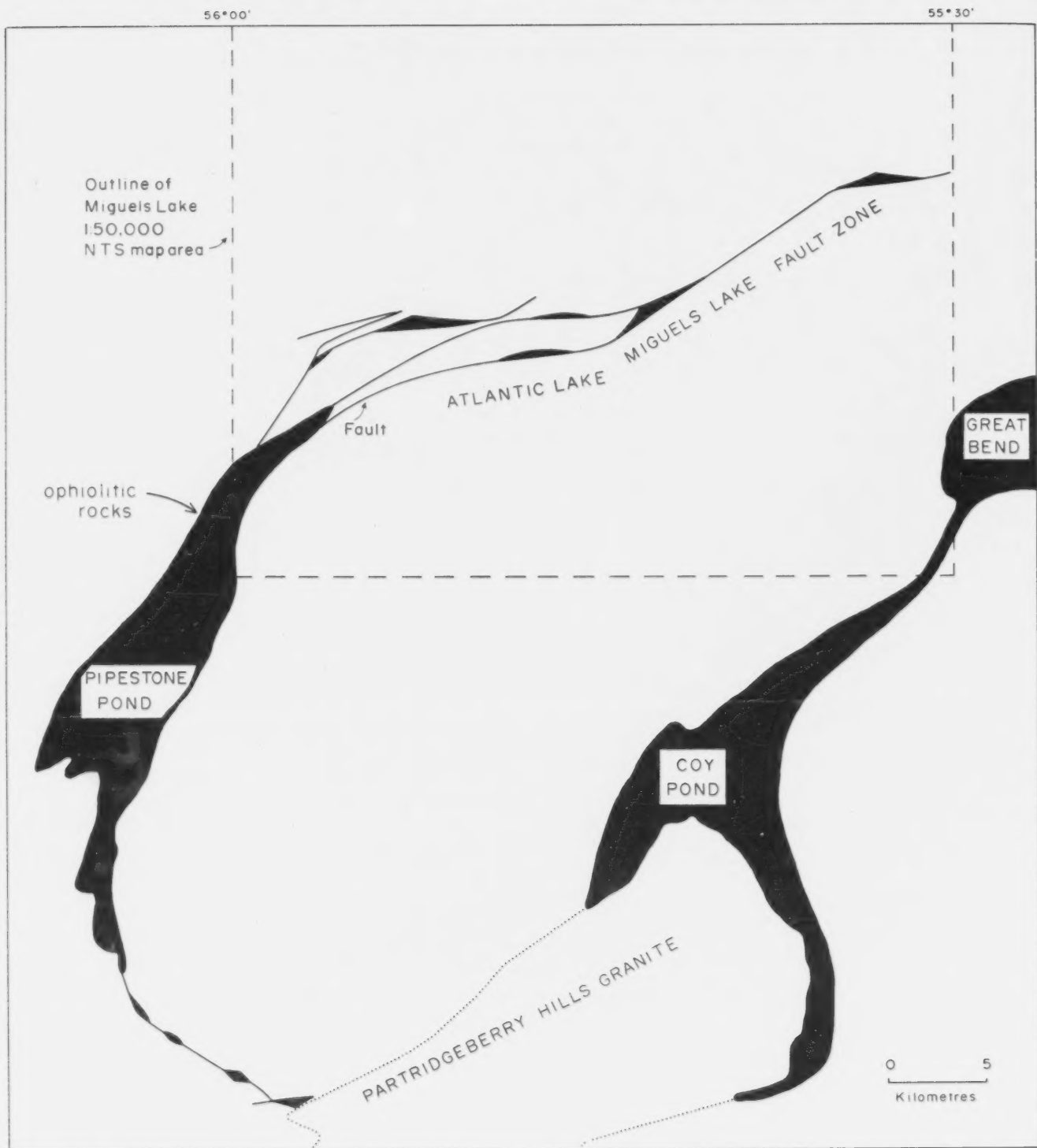


Figure 2: The Great Bend - Coy Pond - Pipestone Pond ophiolite belt. Outcrop pattern modified after Colman-Sadd and Swinden (1981).

migmatitic zone (2b) is cored by gneiss with a large amphibolite component (1). North of the fault zone are three groups of rocks. In the west are mainly Ordovician submarine felsic volcanics (12, 13) and associated sedimentary rocks (11, 15). The northernmost volcanics (13) can be directly correlated with the Tally Pond Formation of central Newfoundland (Kean and Jayasinghe, 1980). In the east are shallow marine clastic sediments (16, 17) and red beds (18); the latter are attributed to the Silurian Wigwam Formation of the Botwood Group (Dean, 1978). The central section is underlain by Devonian or younger subaerial felsic volcanic rocks (21-28) and associated shallow-water sediments (20). These overlie the other units unconformably.

Granitoid intrusions (19) include part of the Overflow Pond Granite (Kean and Jayasinghe, 1980) and a number of small bodies associated with the high grade metamorphic rocks in the south of the area. The age of the intrusions is probably Devonian.

MIDDLE ORDOVICIAN AND OLDER - INSIDE THE OPHIOLITE BELT (UNITS 1-3)

Amphibolite-bearing gneisses (Unit 1)

The gneisses of Unit 1 occur in the centre of the high grade metamorphic terrain in the southwest of the area. They differ from enclosing gneisses of Unit 2b in that they contain substantial amounts of amphibolite which is otherwise absent from rocks surrounded by the ophiolite belt.

The gneisses have a compositional banding on a scale of 5 cm to 1 m. The bands are composed of four principal rock types, which are in order of abundance: granite, amphibolite, sillimanite schist and biotite psammite. The granite is mostly fine grained and contains segregated foliae of biotite, some of which define complex folds within the bands; there are also segregations and bands of unfoliated

pegmatite. The amphibolite has an internal banding reflecting variations in the amphibole to biotite and feldspar ratio; extreme compositions consist almost entirely of amphibole and have grain sizes of over 1 cm. The sillimanite schist is medium to coarse grained and has prominent white 'buttons' of fibrolite; it contains and is cut by segregations and veins of granite pegmatite. The psammite is fine to medium grained and contains varying amounts of biotite. All the rock types are involved in mesoscopic isoclinal folding which also folds the main foliations; some of the amphibolite, however, occurs as irregular blocks surrounded by granite gneiss and abruptly terminates the foliation in the gneiss.

Clastic sedimentary rocks and metamorphic derivatives (Units 2 and 3)

Unit 2 varies in degree of metamorphism from greenschist facies to migmatite as has previously been reported from the Burnt Hill map area (2D/5) to the south (Colman-Sadd, 1981). The character of the original sediments is best observed in the low grade terrain along the Northwest Gander River, where quartz-rich fine grained gray sandstone is interbedded with well laminated gray siltstone and dark gray to black shale. The sandstone beds are 10 cm to 2 m thick. Graded bedding, channelling, load casts, and ripple-drift lamination are common sedimentary structures, suggesting deposition by turbidity currents. Two occurrences of limestone conglomerate have been located close to the river and are thought to form a single horizon. They contain subangular, poorly sorted fragments that mainly consist of sandy limestone. The rock is supported by a matrix of slightly calcareous gray siltstone. It contains disseminations of pyrite and is cut by calcite-pyrite veins. Brachiopods that occur in both the clasts and the matrix indicate an age in the range Late Arenigian to early Caradocian and are most likely to be Llanvirnian (R.

Neuman, written communication, 1982).

An outcrop of conglomerate in the centre of the Miguels Lake area just west of the transmission line is tentatively included in Unit 2a. The clasts consist mainly of fine grained sandstone, are subangular, poorly sorted and up to 10 cm across. The rock is clast supported. The conglomerate is bounded to the south by a tectonically disturbed zone of sandstone, siltstone and shale similar to rock types that form the greater part of Unit 2a.

Metamorphic rocks included in Unit 2a in the southwest of the area are separated from the sedimentary rocks in the southeast by an area of no exposure. The correlation is made with reference to the Burnt Hill area to the south (Colman-Sadd, 1980b). The best exposure is seen in the west between the Pipestone Pond Complex (4) and the gneisses of Unit 1. A progression can be observed from biotite grade rocks close to the ophiolite, through an area where andalusite porphyroblasts are prominent, into rocks with white 'buttons' of fibrolitic sillimanite, and then into migmatite and granitoid gneiss (2b). Sillimanite-bearing metasediments reappear to the east of the migmatite. The characteristic sandstone beds interbedded with semipelite are present throughout Unit 2a. In the migmatitic terrain, fragments of bedded sediment are still recognizable, but in the granitoid gneiss no sedimentary structures are preserved.

Unit 2a has been subjected to one main period of deformation causing tight folds and a penetrative cleavage that in many places is subparallel to bedding. Exposures close to the Great Bend ultramafic complex in the southeast of the area show refolding during a second deformation and the local development of a strain-slip cleavage. The migmatitic rocks (2b) show complex fold patterns attributed to their high ductility during metamorphism.

Unit 3 consists of monotonous interbedded green-gray, very fine grained sandstone, siltstone and laminated siltstone and shale. In most places, the bedding is obscure because contacts are not sharply defined, but where it can be identified, the sandstone and siltstone beds are up to 1 m thick and the laminated siltstone and shale beds up to 10 cm. The sandstone and siltstone are well cleaved with a characteristic spacing of 2 to 5 mm between cleavage surfaces. In the exposures south of Miguels Lake, biotite of probable metamorphic origin is present. Farther west on the transmission line north of Pot Hill, where the metamorphic grade is much higher, the spaced cleavage surfaces are coated with mica, the siltstone and shale beds have become medium grained schists and a few originally calcareous beds contain garnet and actinolite. Quartz veins and a few granitic segregations are present. The rocks on top of Pot Hill have also undergone further deformation and the spaced cleavage is folded into tight folds with a second axial planar crenulation cleavage.

MIDDLE ORDOVICIAN AND OLDER - OUTSIDE
AND INCLUDING THE OPHIOLITE BELT
(UNITS 4-14)

Ophiolitic rocks (Units 4-9)

Rocks representing all levels of the ophiolite suite outcrop in the western part of the area at the northeast end of the Pipestone Pond Complex. Likewise, most levels of the suite may occur in the Great Bend complex in the southeast, but only ultramafic rocks are exposed within the Miguels Lake area. Faulted slices of ophiolitic rocks in the Atlantic Lake - Miguels Lake fault zone variously include peridotite, pyroxenite, gabbro and pillow lava.

Peridotite of Unit 4 is a massive, brown weathering, black rock. The only observed internal structure is a local banding of chromite grains which are otherwise disseminated throughout the

rock. Pyroxene crystals up to 5 mm across form a small percentage of the Great Bend peridotite, but at the Atlantic Lake outcrop they were only seen in loose boulders. All exposures show some degree of deformation. Where least deformed, the rock is cut by random fractures filled with talc, serpentine and asbestos. At the other extreme, the peridotite has been reduced to a well cleaved talc-serpentine schist. This intense deformation occurs locally in the main outcrop at Atlantic Lake and in the exposure just to the north near Great Rattling Brook; it seems to be associated with fault zones trending east-northeast, oblique to the main trend of the Pipestone Pond complex but parallel to the Atlantic Lake - Miguels Lake fault. In both the Pipestone Pond and Great Bend complexes, some exposures have been largely altered to magnesite, but can be recognized as having been originally peridotite by the characteristic disseminated chromite grains. In most cases, the magnesite-rich rock has the appearance of a tectonic breccia with large massive blocks enveloped in a foliated matrix.

Pyroxenite (5) has been found in four small outcrops, all of which are bounded by faults or granite. In the outcrop northeast of Atlantic Lake, the pyroxenite is medium grained and massive, it is cut by randomly-oriented fractures filled with magnesite and although the pyroxenite itself is only mildly sheared close to its contacts, the surrounding peridotite has been reduced to a talc-serpentine schist. The pyroxenite near the Overflow Pond Granite is also medium grained and massive; its contacts are unexposed. Farther east pyroxenite occurs with gabbro in a fault block; it is medium grained with thin layers of coarse crystals and in the northern part of the block it is interlayered with the gabbro. At the confluence of the two branches of Great Rattling Brook, a fault zone is defined by a narrow outcrop of sheared serpentized pyroxenite, parts of which have been altered to magnesite.

Gabbro (6) occurs in close association with pyroxenite around the margin of the Overflow Pond Granite and in the fault block 5 km to the east. In each case, it is medium grained and indistinctly layered. The exposure near the granite is cut by diabase dikes and the gabbro is internally brecciated. Northwest of Atlantic Lake, massive gabbro grades into a slightly foliated, quartz-rich, plutonic rock that may be the edge of a trondhjemite body. The gabbro exposed in Great Rattling Brook in the central part of the area is fractured, but not foliated and is associated with a fine grained siliceous rock of uncertain origin. A single exposure of gabbro has been found in the outcrop on the transmission line; it has a slight penetrative lineation.

Unit 7 consists mainly of mafic pillow lava, breccia and fine grained mafic schist with pillow fragments. It also includes sheets of massive basalt or diabase that may be sills. Black shale and basalt-derived grit are locally interbedded with the lava. Pillows are up to 1 m across; they are generally variolitic and some of them are vesicular. Interpillow material, where present, consists of fine grained mafic schist or carbonate. Pyrite is disseminated in all the rock types of the unit and also occurs as segregations. The outcrop of Unit 7 at Miguels Lake contains mildly deformed pillow lava, as is found farther west, and also sheared lava and strongly mylonitized mafic schist. The latter has a banding with intrafolial folds, and has been brecciated along fracture zones that are parallel to the southern margin of the lake.

The mafic volcanic rocks (7) in the western part of the area are conformably overlain by, and to a small extent interbedded with, conglomerate and black shale and sandstone (8, 9). These sedimentary rocks are considered to form Layer 1 of the ophiolite sequence. They are similar to sediments that directly overlie the pillow lavas of the Coy Pond Complex in the Burnt Hill area (2D/5) to

the south (Colman-Sadd, 1980b). The conglomerate (8) consists almost entirely of mafic volcanic clasts; a few clasts of carbonate, epidote and vein quartz also occur, and in one place pyrite forms a large part of the matrix. Sharp bed contacts are defined by changes in clast size, and bed thickness is not less than 30 cm. The rock is clast supported and the pebbles are slightly rounded and moderately sorted. Clasts are up to 10 cm across in the coarser beds; in the finer beds they are generally less than 5 cm and may be imbricated and graded. A fair cleavage is developed in the finer grained beds.

The conglomerate is in sharp, conformable contact to the southeast with black shale and sandstone of Unit 9. It is presumed that the shale and sandstone stratigraphically overlie the conglomerate, but this is not certain because isoclinal folding has made facing directions of the sediments variable. The shale is pyritiferous and well cleaved. It is interbedded with the sandstone on a scale of 5 mm to 12 cm, with most sandstone beds being about 3 cm thick. The sandstone is very fine grained and generally is massive and ungraded. Most bed contacts are sharp but the tops of the thickest beds grade into parallel laminated shale and sandstone. Sandstone beds commonly truncate shale beds and they themselves vary in thickness and terminate abruptly.

Victoria Lake - Baie d'Espoir Groups (Units 10-14)

Units 11, 12 and 14 are along strike and continuous with rocks included in the Baie d'Espoir Group (Colman-Sadd, 1980a, b; Kean and Jayasinghe, 1980; H.S. Swinden, personal communication, 1981). Unit 13 extends west and southwest into the Victoria Lake Group (Kean and Jayasinghe, 1980). Both groups are Middle Ordovician or older and are considered to be equivalent stratigraphic units belonging

to the 'early arc' sequence of Dean (1977b) (Figure 3).

Unit 10 forms a fault block in the Atlantic Lake - Miguels Lake fault zone and is not directly correlatable with other rocks in the area. It is tentatively attributed to the Salmon River Dam Formation of the Baie d'Espoir Group (Colman-Sadd, 1976) on lithologic grounds. The unit consists of purplish gray, quartz-rich, fine grained sandstone interbedded with well laminated, purplish gray to black siltstone and shale. Thickness of the sandstone beds is generally about 30 cm and that of the siltstone and shale beds varies from 2 cm up to several metres. The more micaceous beds are well cleaved and metamorphism is at about biotite grade.

The semipelitic schist of Unit 11 is part of a much larger outcrop mapped by Kean and Jayasinghe (1980) in the Noel Paul's Brook map area. It consists of thinly bedded and laminated gray shale and siltstone that have been metamorphosed to phyllite. Metamorphism has caused the widespread growth of porphyroblasts, probably of andalusite. These have overgrown the first penetrative cleavage which is generally parallel to bedding, and form augen within the prominent second crenulation cleavage.

Unit 12 was observed at only two exposures. It consists of massive, felsic crystal tuff, which weathers rusty white. Most of the crystals are quartz, up to 3 mm across, and the matrix is fine grained and slightly pyritiferous. The rock resembles pyroclastic rocks observed elsewhere in the Baie d'Espoir Group (Colman-Sadd, 1976).

The Tally Pond Formation (13) consists of felsic pyroclastic rocks. In most exposures, these are fine grained, light gray and feldsparphyric, and contain a few lithic fragments of less than 3 cm in diameter; a poor, steeply

INSIDE THE OPHIOLITE BELT		AGE		OUTSIDE AND INCLUDING THE OPHIOLITE BELT	
Description	Unit		Unit	Description	Potential Mineral Deposits
		Devonian or younger	20-28	Unnamed subaerial volcanic rocks	Epithermal veins; precious metals, U, Sn, W, etc.
				Major unconformity	
Granite intrusion, metamorphism, deformation (?)	19	Devonian	19	Granite intrusion metamorphism, deformation	Vein and disseminated deposits, U, Sn, W, etc.
		Silurian	15-18	Wigwam Fm., etc. Rogerson Lake Conglomerate (?)	
		Upper Ordovician			
Unnamed quartz-rich turbidites and metamorphosed equivalents	2, 3	Middle Ordovician	10-14	Victoria Lake Baie d'Espoir Groups	Kuroko-type massive sulphides Cu, Pb, Zn, Ag, Au
Unnamed amphibolite-bearing gneisses (?)	1	Lower Ordovician	4-9	Pipestone Pond Great Bend Complexes	Cyprus-type massive sulphides Cu, Asbestos, magnesite, chromite in ultramafic rocks
		Cambrian		Oceanic crust	

Figure 3: Stratigraphic classification of units in the Miguels Lake area, with potential exploration targets.

dipping, anastomosing cleavage is generally present. Thick beds of lapilli tuff or tuff breccia occur locally and these generally have a well developed cleavage; they consist of fragments up to 6 cm across, that are dominated by aphanitic rhyolite but also include some mafic volcanic rocks. In some localities, it has been found difficult to distinguish the fine grained, poorly cleaved rocks of the Tally Pond Formation from fine grained undeformed Devonian or younger volcanic rocks (21 to 28) that unconformably overlie them.

The North Steady Pond Formation (14) is not exposed in the Miguels Lake area. Its outcrop is projected from the Burnt Hill area (2D/5) (Colman-Sadd, 1980b).

UPPER ORDOVICIAN AND SILURIAN (UNITS 15, 18)

The Rogerson Lake conglomerate (15) is projected into the map area from the Noel Paul's Brook area (12A/9) where Kean and Jayasinghe (1980) tentatively assigned it to the Silurian. Only one exposure has been found in the Miguels Lake area and that consists of massive, light gray siltstone. It is presumed to represent the finer grained sediments that are interbedded with the conglomerate farther west.

Units 16 and 17 appear to be conformable with the Wigwam Formation of the Botwood Group (18), which elsewhere contains Silurian fossils (Anderson and Williams, 1970; Dean, 1978). They are therefore assigned to the Upper Ordovician or Silurian. Most of Unit 16 consists of green-gray siltstone with interbeds of fine grained, brown-weathering, gray sandstone. The sandstone beds vary in thickness from 1 cm to 2 m and have ripple drift laminations and load casts. The siltstone is well cleaved and the thinner sandstone beds have been broken up and injected along the cleavage surfaces. At the most westerly exposures on the north branch of Great Rattling

Brook, Unit 16 shows a gradation from mainly siltstone to mainly sandstone. Sandstone beds, which are between 10 cm and 1 m thick, have thin interbeds of siltstone. The siltstone is laminated and bioturbated and the sandstone has ripples and trough crossbedding.

Unit 16 grades into rocks of Unit 17 that are similar except that they include interbeds of light red siltstone 3 cm to 1 m thick. As in Unit 16, there are local concentrations of sandstone. Common sedimentary structures are ripples, load casts, and lenticular, flaser and graded bedding.

Rocks of the Wigwam Formation (18) consist of medium to thick bedded red siltstone and gray to grayish red sandstone. Asymmetric, bifurcating ripples occur throughout the unit, and lenticular and flaser bedding are common. Some of the sandstone beds contain mudclasts apparently derived from finer grained beds with mudcracks, and siltstone beds are extensively burrowed. A penetrative cleavage is present in the siltstone beds, but does not affect the sandstone beds.

DEVONIAN

The Overflow Pond Granite (19a) (Kean and Jayasinghe, 1980) is represented by a small area of exceptionally good exposure north of Atlantic Lake. The granite is medium to coarse grained and equigranular. Biotite is the only primary mica observed in the field and red garnet occurs as a common accessory mineral. There is no tectonic fabric and no pegmatite or aplite veins have been found.

Pegmatitic garnet-muscovite granite (19) occurs at two locations in the outcrop of Unit 2a near the southern edge of the map area. Only the more westerly of these occurrences has actually been observed *in situ*; the other is inferred from frost heaved boulders. These granite intrusions are small and resemble the Through Hill

Granite in the Burnt Hill area (Colman-Sadd, 1981), both lithologically and in their location close to the sillimanite isograd.

DEVONIAN OR YOUNGER

The youngest rocks in the Miguels Lake area consist of subaerial volcanics with shallow water sediments occurring around the southern and eastern edges of the outcrop. Eight different units of volcanic rocks have been separated in the field and most of these can be further subdivided into flows, breccias and tuffs. No subvolcanic intrusions have been observed.

There has been little deformation of these rocks. Dips are gentle and the most obvious fold structures are monoclinical flexures that occur in some of the sediments of Unit 20. Cleavage only occurs locally and is thought to be associated with fracture zones. The rocks are presumed to overlie the Ordovician and Silurian with angular unconformity, but the contact has not been observed. In the outcrop of Unit 27, however, a block of cleaved green-gray siltstone that probably belongs to the Botwood Group is surrounded and crosscut by undeformed volcanic breccia and lapilli tuff.

The most widespread sedimentary unit consists of gray sandstone and siltstone (20a). There are smaller outcrops of red siltstone (20b) and gray siltstone containing volcanic blocks (20c). The sandstone beds are all fine grained and in some cases are rich in mica. Bioturbation and asymmetric bifurcating ripples are common throughout Unit 20, but lenticular bedding and scours are restricted to the gray beds, whereas mud cracks and rib and furrow structures occur only in the red siltstones. The westerly outcrop of red siltstone is locally interbedded with tuff of Unit 24.

Brief lithologic descriptions of the volcanic rock types are given in the

map legend (Figure 1). The following discussion emphasizes the mode of occurrence and probable age relationships of the rocks (Figure 4). Unit 21 consists mainly of buff flow banded rhyolite. Breccia, probably formed by autobrecciation during flow, is found in several localities in the central parts of the outcrop. Pyroclastic breccia occurs on the northeast and southwest edges of the more southerly outcrop and contains matrix supported fragments 2 to 10 cm across with alteration rims. The outcrop pattern and apparent overlapping relationships suggest that Unit 21 is older than Units 26, 27, and 28. Its relationship to Units 22 and 25 is unknown.

Rhyolitic crystal tuff of Unit 22 is medium grained and equigranular, and there is no variation across the outcrop. Slabbed samples from the same unit in the Grand Falls area (2D/13) show flattened pumice fragments on the cut surfaces (B.F. Kean, personal communication, 1981), but these are not visible on broken surfaces. The age relationships of Unit 22 to surrounding units is unclear.

Gray, flow banded rhyolite, lacking any kind of phenocrysts, occurs in the northwest corner of the outcrop of Unit 23. To the south, the outcrop consists of tuff and lapilli tuff, containing feldspar and quartz crystals in a fine grained gray matrix. The lapilli consist mainly of pink weathering rhyolite, but also include black feldsparphyric rhyodacite. Generally, the deposit is massive, but at one locality beds 2 to 10 cm thick are defined by changes in grain size. The relationship of Unit 23 to other units is uncertain.

Flow banded purple rhyolite of Unit 24 forms a hill at the southern edge of the outcrop, and this may mark the position of the original vent for the unit. Along the north edge of the hill is a breccia with fragments up to 50 cm across. This passes northwards into massive lapilli tuff, and then farther

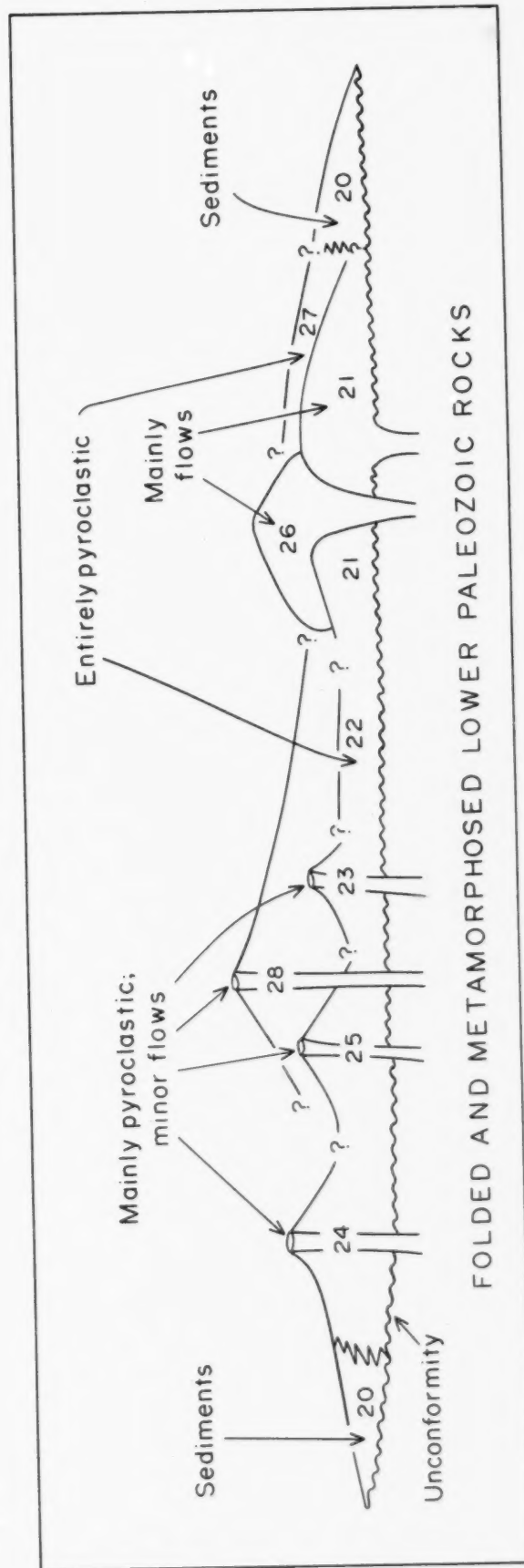


Figure 4: Schematic representation of relationships in the Devonian and younger volcanic and sedimentary rocks (Units 20 to 28).

north and isolated from the main outcrop is finer grained purple and pink tuff that may or may not be part of the same unit. Time relationships of Unit 24 are uncertain.

Unit 25 is formed of purple rhyolite that is lighter coloured and pinker than Unit 24. It appears to be centred at an outcrop of pink and purple flow banded and autobrecciated rhyolite southwest of Stony Lake. To the northwest of this outcrop, the same type of rhyolite occurs in massive lapilli tuff, whereas to the east it forms isolated blocks with alteration rims in a massive gray fine grained matrix.

The prominent topographic feature of Miguels Hill is formed of a roughly circular outcrop of flow banded aphanitic gray and purple rhyolite (26). Complicated flow folding is clearly visible in the excellent exposure. To the south the same rock type is found in a volcanic breccia, thought to be the result of autobrecciation, that forms a prominent south trending ridge. The elevated topography and overlapping outcrop of Unit 26 strongly suggest that it is younger than Unit 21. Its relationships to Units 28 and 27 are less clear, since it may have been extruded through them or it may have formed a pre-existing topographic high that deflected their respective pyroclastic flows.

Unit 27 consists entirely of lapilli tuff and tuff with minor breccia. It varies in colour from dark green, through black, to dark gray, but is everywhere characterized by white rectangular feldspar crystals and in most exposures contains abundant fragments of pink weathering rhyolite. The pink rhyolite fragments are generally equidimensional, but a few form gently undulating slabs with finely divided, 'frayed' edges. One fragment of pink rhyolite was found that, itself, contains a fragment of the same black feldsparphyric rhyodacite occurring in the matrix.

Dark gray to black rhyodacite(?) of Unit 28 forms a large flat lying sheet that appears to overlap onto neighbouring units, although the relationship with the rhyolite of Miguels Hill (26) is ambiguous. About 2 km west of Stony Lake the rhyodacite occurs as strongly flattened welded tuff and as probable flows with interbanded pumiceous and nonvesicular layers up to 50 cm thick. The eutaxitic foliation and flow banding in these rocks has steep dips and is tightly folded; the outcrop is roughly circular with a diameter of about 900 m. Surrounding this central zone is a circular outcrop of breccia and lapilli tuff between 500 m and 2 km in width. These rocks are massive without any measurable foliation. They consist of fragments up to 30 cm across, of flow banded and pyroclastic rhyodacite, pink feldsparphyric rhyolite, and a variety of other minor constituents; the fragments are angular and unsorted. The greater part of Unit 28 is formed of lapilli tuff which surrounds the central zone of breccia and intensely flattened or flow banded rhyodacite. The lapilli tuff is formed of angular fragments that are generally about 1 cm across but also include a few blocks up to 10 cm across. There are fewer accidental fragments than in the breccia, but flattened pumice is common and in many places allows measurement of a shallowly dipping eutaxitic foliation. In the promontory of Unit 28's outcrop north of Miguels Hill, the flattening of the pumice is extreme and the rock has been remobilized to form flow folds of the eutaxitic foliation. Rare occurrences of bedded and sorted tuff within the rhyodacite sheet suggest that it is formed of more than one cooling unit, but the scarcity of exposure and lack of topographic relief have prevented any detailed subdivision.

OTHER UNITS

Below are listed units that are too restricted to be shown on the sketch map, but which are separated on the 1:50,000 map by Colman-Sadd and Russell (1981).

1. Diabase dikes have intruded the sedimentary rocks of Unit 16. Their age is unknown.

2. Volcanic breccia, consisting of angular fragments of gray aphanitic rhyolite between 10 and 50 cm across, are exposed in a 30 m cliff face at the unconformable contact between Units 13 and 22. The breccia is thought to belong to the Devonian or younger volcanic sequence, but its relationship to individual units in this sequence is unknown.

3. Light to dark gray rhyodacite occurs in several exposures south and east of Miguels Hill. It contains scattered quartz phenocrysts in an aphanitic, structureless matrix and in one locality appears to be intrusive into an autobrecciated rhyolite flow of Unit 26.

4. Large conglomerate boulders form a small island in the central part of Miguels Lake. They are formed of clasts of gray and red siltstone, pink to red rhyolite, intensely sheared mafic volcanic rocks and fine grained limestone. Some of the siltstone and most of the limestone clasts have a cleavage. The sheared mafic volcanic rocks appear to be derived from Unit 7 as exposed on neighbouring islands in Miguels Lake. The conglomerate contains lenses of well sorted and locally graded sandstone, and there are beds of calcareous siltstone between 2 and 60 cm thick. The conglomerate itself is generally poorly sorted and clast supported; the clasts vary in size from 1 mm to 50 cm and are subangular to subrounded. The rock is undeformed and is appreciably less indurated than other conglomerates found in the map area (*i.e.* in Units 2a and 8). In view of this and because some of the clasts were most likely derived from the subaerial volcanic rocks to the west (Units 20-28), a Devonian or younger age is suggested.

STRATIGRAPHIC AND STRUCTURAL HISTORY

Most of the original geological relationships in the Miguels Lake area have been obscured by faulting and must be inferred from the regional geology of the Newfoundland Central Mobile Belt. A stratigraphic classification is presented in Figure 3 from which it is apparent that the units outside and including the ophiolite belt are easily reconcilable with the groupings of Dean (1977b). The units inside the belt, however, are lithologically distinct, although they seem to be about the same age as the pre-Caradocian island arc and possibly the oceanic crust. Their significance is discussed after the immediately obvious correlations of the rocks outside the belt have been made.

The dismembered pieces of the ophiolite suite (4-9) are comparable to the various levels of the structurally intact Coy Pond Complex to the south (Colman-Sadd, 1981). They can be considered as oceanic crust and, following the model of Strong *et al.* (1974), this crust is interpreted as the basement to a Middle Ordovician and older island-arc and back-arc basin. A minimum age for the oceanic crust is provided by Llanvirn-Llandeilo fossils in sediments that overlie the Gander River ultrabasic belt north of Gander Lake (Blackwood, 1978; Stouge, 1979).

The 'early arc' sequences of the Victoria Lake and Baie d'Espoir Groups (10-14) are dated as pre-Caradocian (Kean and Jayasinghe, 1980) and Caradocian or older (Colman-Sadd, 1976) respectively. Relationships in the western part of the Central Mobile Belt indicate that at least parts of the 'early arc' overlie the ophiolitic rocks conformably (Marten, 1971; Upadhyay *et al.*, 1971) and that formation of the arc began no later than the Arenigian (Snelgrove, 1931).

The original stratigraphic position of the Rogerson Lake conglomerate (15) cannot be conclusively determined in

either the Miguels Lake or Noel Paul's Brook areas (Kean and Jayasinghe, 1980), but it may represent a facies similar to the Goldson Formation in the Upper Ordovician to Silurian post-Caradocian flysch. The transition to shallow marine sediments and red beds in the Silurian is represented by rocks of the Wigwam Formation (18) and associated units (16, 17). No 'mature island arc' volcanism of Silurian age has been recognized in the Miguels Lake area.

The presence of two sequences of Middle Ordovician and older rocks, one within the ophiolite belt and the other outside it presents serious stratigraphic and structural problems. The turbidites of Units 2 and 3 are rich in quartz and have no obvious volcanic detritus; they appear to be derived from a continental source. The Victoria Lake and Baie d'Espoir Groups (10-14), which are of equivalent age to Unit 2 and border about three quarters of the ophiolite belt on the outside, consist either of volcanic rocks or of detritus from a volcanic source. Although these rocks are everywhere faulted against the ophiolite and cannot be proved to lie directly on it, evidence from elsewhere in the Central Mobile Belt suggests that they may have once done so (Marten, 1971; Upadhyay *et al.*, 1971). There is no evidence that the rocks of Units 2 and 3 occur anywhere outside the ophiolite belt. This being so, there appear to be two contrasting sequences of the same age in the same area. The implication is that one of them is allochthonous.

The rocks of the ophiolite belt face outwards towards the Victoria Lake and Baie d'Espoir Groups, which are thought to have originally overlain them. This sequence is therefore thought to form the structurally higher, allochthonous sheet. If this interpretation is correct, the allochthonous sheet probably includes all of the Baie d'Espoir Group as far southeast as the Day Cove Thrust, and the Davidsville Group which appears to be contiguous

with it (Colman-Sadd, 1980c). The minimum displacement on such an overthrust is about 80 km.

The Great Bend and Coy Pond Complexes are both near vertical and the Pipestone Pond Complex dips west at about 60° (Stuckless, 1975). If these rocks do in fact form the base of an overthrust sheet, there must have been much subsequent modification of the structure. This would also be indicated by the inconsistency of the ophiolite outcrop (Figure 2); the thick continuous ophiolite complexes occur on the northerly trending sections of the belt, whereas the ophiolitic rocks on the more easterly trending sections occur in small isolated fault slices. Furthermore, where the contacts of the Great Bend and Coy Pond Complexes are exposed, the sediments of Unit 2 inside the ophiolite belt have been thrust or reverse faulted over the previously upturned ultramafic rocks.

If the major structure inferred from stratigraphic and paleontologic observations can be correlated with the minor structures observed in the field, the most likely time of overthrusting is Late Silurian or Early Devonian. All of the Lower Paleozoic rocks up to and including the Silurian Wigwam Formation have a single penetrative cleavage associated with isoclinal folds, on which are locally superimposed second deformation structures. Colman-Sadd (1980c) has suggested that this first penetrative deformation can be correlated through all the Lower Paleozoic rocks in the eastern part of the Central Mobile Belt so that all the deformation in these rocks can be considered as Acadian.

Metamorphism is also considered to be of Acadian age because of its relationship to the deformation. Outside of the ophiolite belt, where metamorphism is in the greenschist facies, it appears to have followed the onset of the main deformation, since structures formed by this deformation show evidence

of having been imposed on poorly consolidated sediments. Within the ophiolite belt the metamorphic isograds have been superimposed across the major fold structures (Colman-Sadd, 1980d) so it is inferred that equilibrium was not reached until after the main period of deformation. The spatial conformity of the isograds with the ophiolite belt does however indicate a genetic link with the deformation that caused the updoming of the rocks inside the belt.

The Overflow Pond Granite (19a), which may place a younger limit on the main deformation because it postdates the major structures, has been dated at 389 ± 6 Ma and 393 ± 5 Ma using the $^{40}\text{Ar}/^{39}\text{Ar}$ method (Dallmeyer, 1980).

The Devonian or younger volcanic and sedimentary rocks (20 to 28) clearly postdate the deformation and metamorphism of the Lower Paleozoic rocks on which they lie unconformably, but further than that their age remains unknown.

MINERAL POTENTIAL

The Miguels Lake area contains units representing most of the major stratigraphic divisions of the Newfoundland Central Mobile Belt. Consequently, there are a variety of targets for mineral exploration (Figure 3), but only two of these have been prospected in any detail.

The ultramafic rocks (4, 5) have showings of asbestos and magnesite, and chromite is disseminated throughout the peridotite. Minorex currently holds claims around the asbestos showings near Atlantic Lake, where cross-fibre veinlets 1 to 3 mm wide are common but not abundant in exposures of peridotite (4). Asbestos fibres 1 to 4 mm long were reported by Coleman (1954) from the Great Bend complex. Magnesite occurs in fault zones near Atlantic Lake, along Great Rattling Brook and on the Northwest Gander River; literature on the magnesite occurrences in the Great

Bend complex has been reviewed by Colman-Sadd and Swinden (1981). No chromite concentrations comparable to those present in the Pipestone Pond and Coy Pond Complexes (Snelgrove, 1934) have been found in the Miguels Lake area.

The mafic lavas and tuffs of Unit 7 form the upper part of the ophiolite sequence and as such have potential for Cyprus-type massive sulphide deposits. Disseminated pyrite is a common constituent of the rocks and Dean (1977a) reported a locally derived boulder of basalt containing stringers of pyrrhotite and chalcopyrite and assaying 0.78 percent copper.

Felsic volcanic rocks belonging to Dean's (1977b) 'early arc' sequences are represented by Units 12 and 13. The former is along strike from the Great Burnt Lake belt where mafic volcanic rocks are host to two significant volcanogenic massive sulphide deposits (Colman-Sadd and Swinden, 1981). Unit 13 is part of the Tally Pond Formation which contains pyrite, sphalerite, galena, and chalcopyrite mineralization near Burnt Pond in the neighbouring Noel Paul's Brook area (Dimmell, 1974; Kean and Jayasinghe, 1980).

The Middle Ordovician and older rocks inside the ophiolite belt (1-3), together with the Upper Ordovician and Silurian sediments outside the belt (15-18) seem to have little economic potential. The potential of the granitic rocks (19) may be higher since the two small intrusions in Unit 2 are similar to the Through Hill Granite, which has been rated as one of the more favourable granites for tin and tungsten mineralization in south-central Newfoundland (Colman-Sadd and Swinden, 1981).

The Devonian or younger volcanic rocks (20-28) have been the subject of several reconnaissance studies, but only Amoco have done any detailed work, and then only in a very restricted area

(Donovan, 1978). Possible targets are epithermal veins carrying precious metals, uranium or other mineralization, and tin-tungsten deposits similar to those at Mount Pleasant in New Brunswick (Dagger, 1972). The likelihood of an economic deposit of the latter type may have been significantly reduced by the present mapping project, because no subvolcanic intrusions have been found outcropping at the surface. The apparent absence of significant veining or alteration, however, can easily be explained by poor exposure, especially since altered zones may be less resistant to erosion and so might be more likely to occur in drift-filled valleys. The possibility of uranium mineralization is suggested by an exposure in the northern outcrop of Unit 24 which gave a radioactivity reading of 700 cps against a background of 150 cps.

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GEOLOGY OF THE GREAT GULL LAKE (2D/6) - DEAD WOLF POND AREA (2D/10),

NEWFOUNDLAND

by

R. Frank Blackwood and L. Green

INTRODUCTION

The Great Gull Lake (2D/6) map area and the west half of the Dead Wolf Pond (2D/10) map area (that part underlain by the Middle Ridge Granite) were mapped on a 1:50,000 scale during the 1981 field season. This completes field work for the Gander Rivers Project, initiated in 1978 to map the GRUB line and adjacent rocks from the mouth of Gander River in the northeast to Great Gull Lake in the southwest.

The northern half of the Dead Wolf Pond (2D/10) area (Figure 1) is accessible from an old, rough woods road that branches off the Trans Canada Highway near Gambo and runs approximately east-west through the map area along the north side of Dead Wolf Pond. The southwestern part of this area as well as the area north and east of Great Gull Lake in the Great Gull Lake (2D/6) area (Figure 2) were mapped by fly-camps positioned by fixed wing aircraft and helicopter. The western part of the Great Gull Lake area is readily accessible from the Bay d'Espoir Highway.

Bedrock exposure is fair in the Middle Ridge Pond area but extremely poor in the western part of the Great Gull Lake map area. The Middle Ridge Granite is generally poorly exposed; the best areas of outcrop occur southeast of Dead Wolf Pond and east of Caribou Lake in the Dead Wolf Pond map area and south of Little Gander Pond and northwest of Newton Lake in the Great Gull Lake map area.

The northern part of the Middle Ridge Granite (Figure 1) was mapped on a one inch to four miles scale by Jenness

(1963) for the Geological Survey of Canada. He showed it as intrusive into the Ordovician Gander Lake Group. The southern part of the granite was outlined by Anderson and Williams (1970) as part of a regional Geological Survey of Canada 1:250,000 mapping program that included all the Great Gull Lake map area. A pronounced metamorphic aureole was indicated around the Middle Ridge Granite and a smaller granite body at Third Berry Hill Pond. They also defined some of the ultramafic rocks and a quartz-feldspar porphyry, interpreted as intrusive or extrusive in Ordovician metasedimentary rocks of the Gander Lake Group. Sedimentary rocks in the northwestern part of the Great Gull Lake map area were indicated as undivided Ordovician and Silurian. The southeastern part of the West Gander Rivers area (2D/11), *i.e.* the area west of the Middle Ridge Granite (Figure 1), was mapped in 1980; for details see Blackwood (1981).

GENERAL GEOLOGY

The map areas comprise six major subdivisions:

- (1) Lower Ordovician or earlier ultramafic rocks (1).
- (2) Lower Ordovician or earlier sedimentary rocks of the Gander Group (2, 3).
- (3) Middle Ordovician volcanogenic and associated sedimentary rocks (4, 7).
- (4) Middle Ordovician and later sedimentary and volcanic rocks of the Davidsville Group (8-10).
- (5) Ordovician or Silurian sedimentary rocks (11, 12).
- (6) Devonian granitic rocks of the Middle Ridge Granite (13-15),

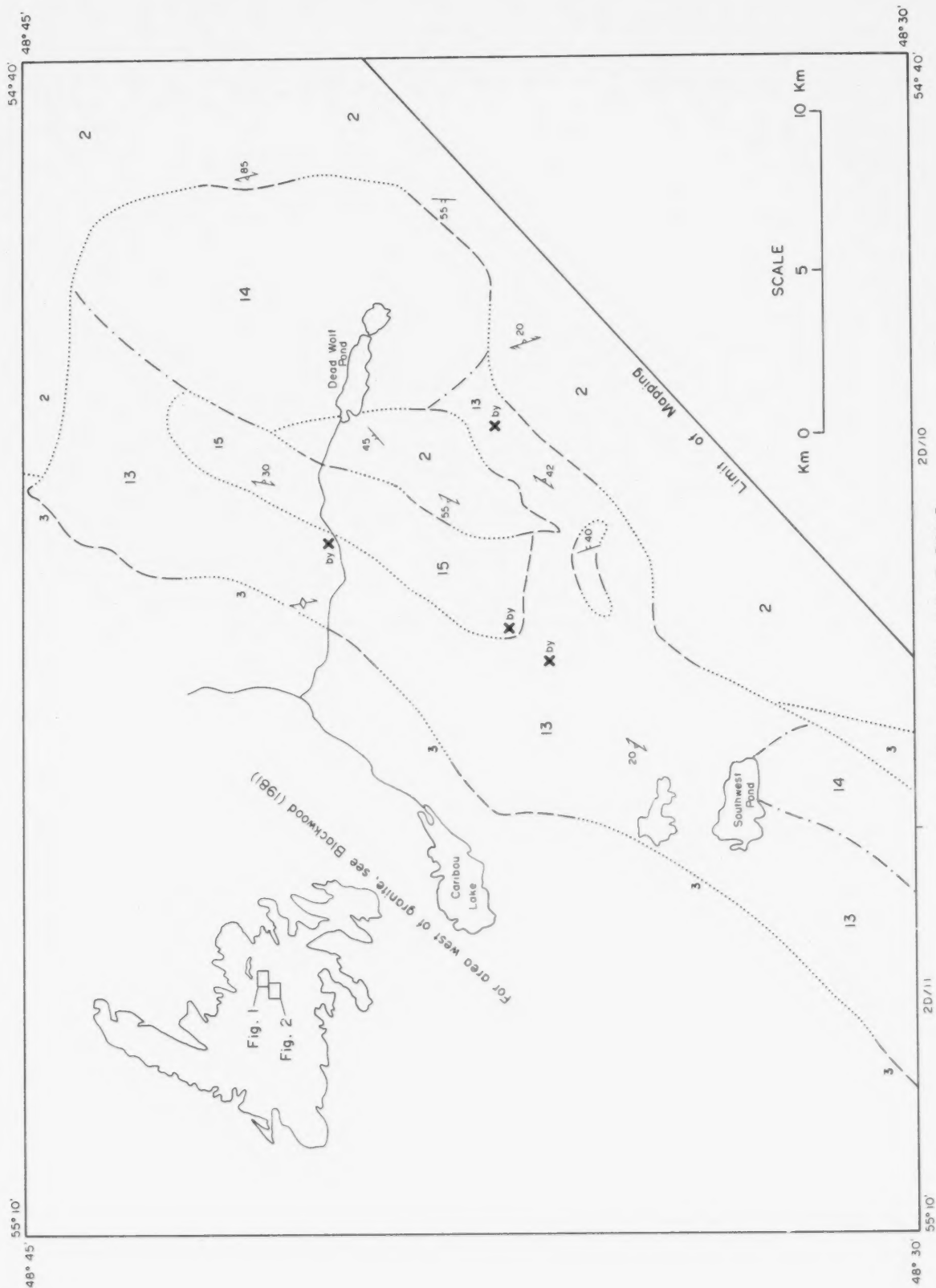


FIG. 1 DEAD WOLF POND

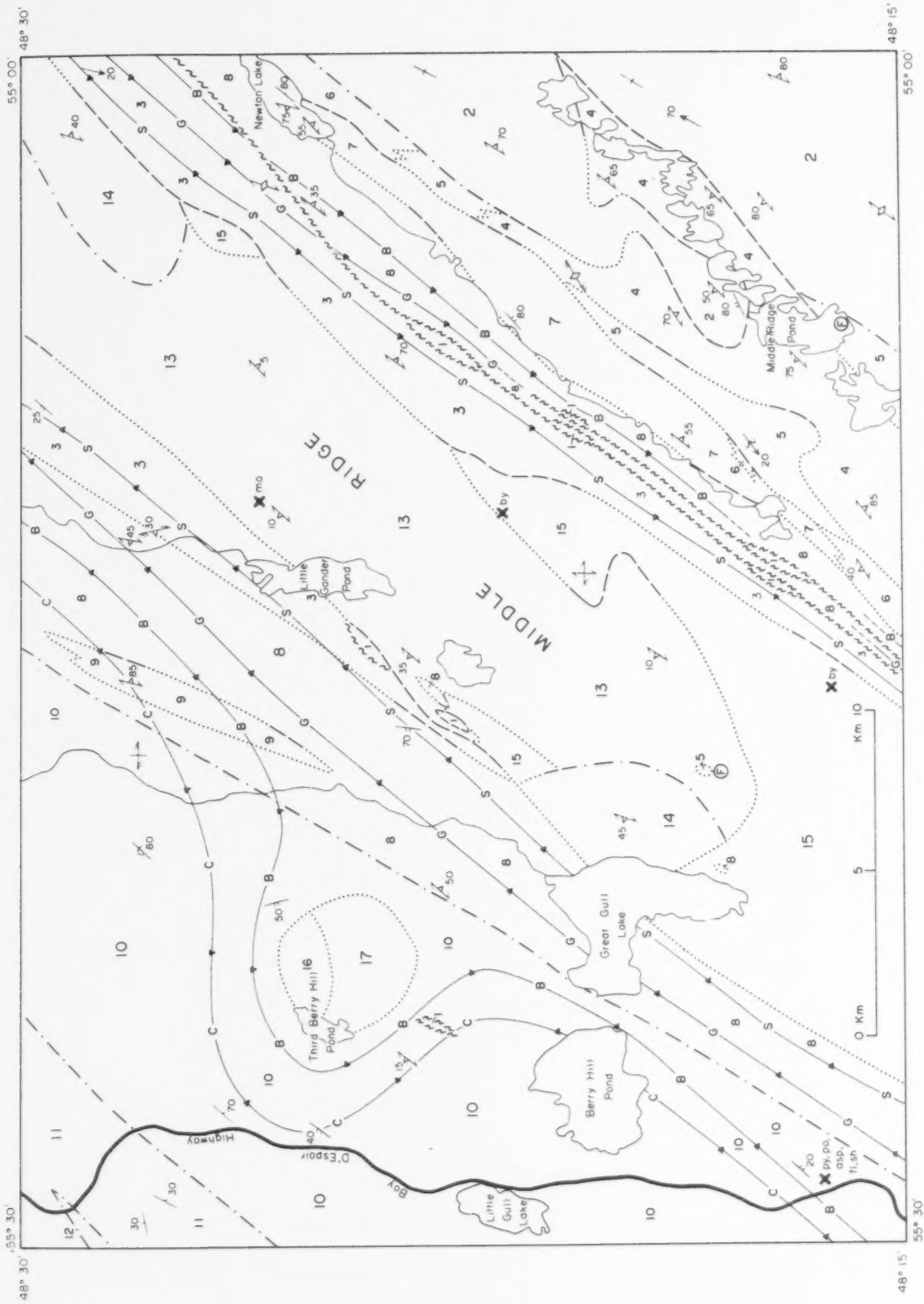


FIG. 2 GREAT GULL LAKE

LEGEND

DEVONIAN (?)

THIRD BERRY HILL POND GRANITE (16 and 17)

- 17 Fine to medium grained, muscovite greater than biotite, garnetiferous leucogranite. Locally contains quartz and feldspar phenocrysts.
- 16 Coarse grained, feldspar porphyritic, biotite granite.

MIDDLE RIDGE GRANITE (13 - 15)

- 15 Fine grained to pegmatitic, muscovite greater than biotite, garnetiferous, leucogranite.
- 14 Coarse grained, feldspar porphyritic, muscovite-biotite granite with rare garnets.
- 13 Medium to coarse grained, muscovite-biotite granite with minor garnets.

ORDOVICIAN OR SILURIAN

- 12 Polymictic conglomerate.
- 11 Laminated siltstone and minor, fine grained, thinly bedded sandstone.

MIDDLE ORDOVICIAN AND LATER

DAVIDSVILLE GROUP (8 - 10)

- 10 Fine to coarse grained, thickly bedded graywacke interbedded with gray siltstone and slate.
- 9 Blue quartz-feldspar porphyry.
- 8 Slate and thinly bedded siltstone.
- 7 Polymictic conglomerate and sandstone.
- 6 Mafic to intermediate volcanoclastic rocks, felsic crystal lithic tuff and minor basalt.
- 5 Graphitic slate and gray siltstone.
- 4 Quartz-feldspar porphyry with a fine grained greenish-gray matrix.

LOWER ORDOVICIAN OR EARLIER

GANDER GROUP (2 and 3)

- 3 Psammite, semipelite and pelite with minor concordant amphibolite bands and minor quartzite.
- 2 Fine to coarse grained, light gray, arkosic sandstone with minor gray slate and grayish-white quartzite; psammite.
- 1 Serpentinite, minor magnesite, pyroxenite and peridotite.

SYMBOLS

Mineral isograd, approximate position (cordierite, biotite, garnet, staurolite) C.B.G.S

MINERAL OCCURRENCES

Pyrite	py
Pyrrhotite	po
Arsenopyrite	asp
Molybdenite	mo
Beryl	by
Scheelite	sh
Fluorite	fl

and the Third Berry Hill Pond Granite (16, 17).

ULTRAMAFIC ROCKS (UNIT 1)

Ultramafic rocks and their altered equivalents occur in narrow, northeast trending fault slivers on either side of Middle Ridge. One body forms a large raft in the Middle Ridge Granite southwest of Little Gander Pond and a single occurrence of peridotite was mapped north of Berry Hill Pond. These rocks are interpreted as being correlatives of the GRUB line (Blackwood, 1979) defined in the north-northeast.

Serpentinite and pyroxenite constitute most of the zones adjacent to Middle Ridge. The light brown weathering serpentinite (possibly originally peridotite) contains relict pyroxene crystals and locally a fish-scale structure is developed. The tan weathering pyroxenite is generally massive. Talc, tremolite and magnesite are variably developed in association with these ultramafic rocks. A 2 to 4 mm spaced cleavage is locally developed in the serpentinite; it becomes a pronounced schistosity in serpentinite and magnesite along faulted contacts east of Middle Ridge. All these rocks exhibit hornfels textures related to the intrusion of the Middle Ridge Granite, particularly the enclave and zone adjacent to the granite contact southwest of Little Gander Pond. The serpentinite is recrystallized to form a pseudo-spinifex texture (Evans and Trommsdorff, 1974) with 1-4 cm long and 1-2 mm wide, olivine crystals that are disposed in a radiating, criss-crossing pattern. The interstitial material is probably antigorite and commonly triangular in shape. Also, talc rosettes overprint the foliation in talc-tremolite schist. The grayish brown weathering peridotite north of Berry Hill Pond is massive.

GANDER GROUP (UNITS 2 AND 3)

The Gander Group (McGonigal, 1973) occurs on either side of the Middle

Ridge Granite and also in the southeast corner of the Great Gull Lake map area. In the latter area, it consists of fine to medium grained, light gray to white weathering, arkosic sandstone (Unit 2). The sandstone is interbedded locally with minor quartzite, siltstone and slate. A clastic texture commonly marks the arkose and quartzite with well rounded and equigranular quartz grains being locally quite prominent. Bedding generally varies from 30 to 50 cm thick, but may be as thin as 1 to 3 cm or as thick as 2 m; crossbedding occurs locally. Siltstone beds, 2 mm to 3 cm thick, are interbedded with the sandstone. Minor, 25 to 30 cm thick conglomerate beds containing mostly arkose clasts also occur. Unit 2 occurs east and north of the Middle Ridge Granite in the Dead Wolf Pond map area and forms two large enclaves within the granite. It mostly comprises fine grained, gray psammite and semipelite in that region. The psammite commonly contains a fine, 1 to 3 mm wide pinstripe banding defined by disoriented biotite porphyroblasts.

The main foliation is a widely spaced, 2 mm to 2 cm, phyllitic cleavage which overprints Unit 2 south of Newton Lake (Figure 2). It transposes a finer bedding parallel foliation and is axial planar to variably plunging, moderate to tight folds. The main fabric is mimetically recrystallized to form fine to medium grained muscovite-biotite schists where Unit 2 is adjacent to the Middle Ridge Granite in the Dead Wolf Pond area.

Unit 3 occurs adjacent to the western contact of the Middle Ridge Granite (Figures 1 and 2) and also along the granite's eastern contact in the Great Gull Lake map area. It is generally more pelitic than Unit 2 and is conformable with that unit along the south shore of Gander Lake in the northeast (Blackwood, 1980). Unit 3 comprises psammite, semipelite and pelite beds that are 8 to 40 cm thick; the psammite commonly contains 1 to 4 mm laminations. Minor, 12 cm thick, quartzite beds occur locally. However,

the most distinctive aspect of Unit 3, and the main reason for separating it from Unit 2, is the presence of rare 30 cm wide concordant amphibolite bands. These bands are conformable with the enclosing metasediments and are interpreted to represent mafic volcaniclastics.

Unit 3 occurs within the metamorphic aureole of the Middle Ridge Granite and consequently is dominated by hornfels textures. Staurolite porphyroblasts range from 4 mm to 2 cm in length and are common in pelitic units. Garnet and biotite occur throughout, with the latter commonly forming oriented, 2 to 6 mm long, tabular porphyroblasts. Disoriented biotite also accentuate the laminations in recrystallized psammite. These porphyroblasts overprint the mimetically recrystallized main foliation. Locally, a widely spaced strain-slip cleavage appears to form augen around some of these porphyroblasts.

VOLCANOGENIC AND ASSOCIATED SEDIMENTARY ROCKS (UNITS 4-7)

Porphyry, flows, tuffs, conglomerate and slate form a northeastward thinning wedge in the Middle Ridge Pond - Newton Lake area (Figure 2). These rocks are conformable with Unit 2 of the Gander Group and represent an abrupt change in lithofacies from the relatively mature arkosic sandstones. The Gander Group is succeeded by the Middle Ordovician Davidsville Group to the north where the change in lithofacies occurs in a fairly regular fashion from east to west and without much of a volcanogenic component. The facies change in the Middle Ridge Pond - Newton Lake area is more easterly situated and interpreted to represent a southwestward interdigitating of the Gander Group with Middle Ordovician volcanics and turbidites.

Unit 4 is a quartz-feldspar porphyry that occurs in the Middle Ridge Pond area. It contains subhedral to

euhedral quartz and plagioclase phenocrysts that are generally evenly distributed in a fine grained, steel gray to grayish green, felsic matrix. The quartz phenocrysts range from 1 to 7 mm across and are translucent to milky white. They commonly are square or triangular in cross-section with dipyrarnidal shapes occurring locally. The plagioclase phenocrysts range from 2 mm to 1.5 cm across and are light green. They generally have rectangular or square outlines and locally contain oscillatory zoning. The relative abundance of quartz and feldspar phenocrysts varies slightly for different parts of the unit. Chlorite and disseminated pyrite are locally developed in the matrix. Finer grained versions of the porphyry (phenocrysts are less than 4 mm across) were observed in two contact areas, east and north of Middle Ridge Pond. Its eastern contact is concordant with arkosic sandstone (Unit 2) of the Gander Group; the fine grained porphyry is locally fragmental along its contact with conglomerate north of Middle Ridge Pond and apparently grades into it. Unit 4 is interpreted as a syndimentation intrusive porphyry and/or a porphyritic lava flow.

The porphyry varies from strongly foliated to undeformed. Where most intensely developed, the fabric has a cataclastic component marked by a well developed augen structure and streaked feldspar. The undeformed parts of the porphyry are generally marked by a coarse grained phenocryst rich phase. Generally a weak to moderate foliation overprints the unit. Locally, the main fabric is transposed by a strain-slip cleavage. This is best seen in the fine grained porphyry phase where the main fabric is also well developed.

Unit 5 consists of interbedded slate and siltstone. Beds in the slaty material are 0.5 to 6 cm thick; the more siliceous, silty interbeds are approximately 12 cm thick. The area along and south of Middle Ridge Pond is

marked by black graphitic slate and siltstone containing graptolite fragments. These fossils have been dated as Middle Ordovician (Anderson and Williams, 1970). Similar graphitic slate occurs south of Newton Lake where it is gradational over 5 m with light gray bedded psammite similar to Unit 2. Graptolitic slate also forms a raft in the Middle Ridge Granite east of Great Gull Lake. A strong slaty cleavage overprints most of Unit 5; the enclave in the Middle Ridge Granite is hornfelsed with fine grained white mica replacing the graptolites.

Unit 6 consists mostly of mafic to intermediate volcanoclastic rocks, including some felsic tuffs. The volcanoclastic rocks are fine to coarse grained and green to grayish green. Feldspar and quartz grains range from 1 to 3 mm across and occur in a chloritized matrix. Locally, isolated epidotized clasts up to 20 cm long occur and are interpreted as volcanic bombs. Pinkish white to purplish red crystal lithic tuff is developed locally in the southernmost outcrop area of Unit 6. It contains quartz and feldspar fragments less than 3 mm across and lithic clasts 0.5 to 1.5 cm long. These rocks are interlayered in the same area with mafic tuffs (which contain siliceous lithic clasts) and mafic flows. The massive(?) flows are basaltic and/or andesitic in composition and generally porphyritic, with 1 to 3 mm plagioclase phenocrysts. They are also locally vesicular or amygdaloidal, containing calcite and epidote amygdules. A sericite or chlorite foliation is well developed throughout Unit 6.

Unit 6, southeast of Newton Lake, is gradational with the quartz rich sandstones of Unit 2 and elsewhere is interbedded in the contact area with slates of Unit 5.

Unit 7 comprises gray polymictic conglomerate and interbedded sandstone which occurs in a linear belt southwest of Newton Lake. Clasts in the

conglomerate consist of fine grained, light gray, felsic volcanics, psammite, arkose, slate and quartz-feldspar porphyry similar to Unit 4. Rare, soft, black clasts of chlorite and/or serpentinite also occur. The clasts are matrix supported, angular to round, poorly sorted, and range from 0.5 to 35 cm in diameter; most, however, are pebble size. Medium to coarse quartz and feldspar grains generally form the matrix. Locally, however, the matrix is very fine grained, suggesting some sort of debris flow. The conglomerate is not well bedded, but where developed, e.g. Newton Lake area, bedding varies in thickness from 30 cm to 1.5 m. Interbedded sandstone and pebbly siltstone occur as 2 to 20 cm thick beds. Fine grained quartzite (containing minor, bright green, fuchsite bearing clasts) is interbedded with rare reddish brown conglomerate in the Newton Lake area. Laminated siltstone, black slate and granule conglomerate containing blue quartz grains occur with pebble conglomerate along the lake shore. A pronounced cleavage overprints the conglomerate; locally, clasts are flattened and form augen structures in the foliation planes.

Unit 7 overlaps Units 4, 5 and 6 and forms a westward limit for this volcanogenic-sedimentary assemblage. It is the youngest unit of the four since it contains detritus from the others, particularly the quartz-feldspar porphyry. This implies a general westward facing direction for this assemblage of rocks.

DAVIDSVILLE GROUP (UNITS 8-10)

The Davidsville Group (Kennedy and McGonigal, 1972) occurs west of Middle Ridge except for a narrow belt of slate and siltstone, tentatively included in the group, that occurs east of Middle Ridge (Figure 2). It is interpreted to conformably overlie the Gander Group (Blackwood, 1980) except where contacts are fault modified in association with emplacement of ultramafic rocks, e.g. east of Middle Ridge.

Unit 8 forms a linear belt on each side of Middle Ridge. It consists of grayish black to gray slates, pelite and semipelite with interbedded siltstone and minor fine grained sandstone. The slates form 1 to 8 cm wide beds that commonly contain 2 to 6 mm laminations. Siltstone beds are generally light gray and 2 to 10 cm thick. Intensely foliated black pelite is generally found in fault contact with the ultramafic bodies. The main tectonic fabric in Unit 8 varies from a slaty-phyllitic cleavage to a muscovite-biotite schistosity, depending upon its proximity to the Middle Ridge Granite. Within the granite's metamorphic aureole, cordierite, biotite and garnet porphyroblasts are common. These minerals overprint the mimetically recrystallized schistosity. A locally developed strain-slip cleavage transposes the main foliation.

Thinly bedded slate and siltstone of Unit 8 are interpreted as conformable with Unit 3 of the Gander Group. In fact, the more pelitic top (Unit 3) of the Gander Group probably represents the transition between the mature arkosic sandstone of Unit 2 and distal turbidites of the Davidsville Group (Unit 8). Rocks included in Unit 8 east of Middle Ridge may be continuous with the volcanogenic and sedimentary assemblage in that area. However, contacts are not exposed and the presence of a local cataclastic fabric in the western part of Unit 7 conglomerates may indicate that a fault separates Units 7 and 8. Unit 8 is also separated from Unit 3 of the Gander Group by a zone of faulting and emplacement of ultramafics in that area.

Unit 9 forms a lens in Unit 8 northwest of Little Gander Pond (Figure 2). It is a quartz-feldspar porphyry consisting of blue quartz and plagioclase crystals, ranging from 2 to 8 mm across. Locally, in the northeastern part of the unit, the crystals appear to form clasts of varying concentrations in a fine grained, phyllitic matrix. Here poorly

developed bedding and minor interlayered slate occur, suggesting the porphyry originated as a crystal tuff. A penetrative foliation overprints Unit 9.

Unit 10 consists mostly of fine to coarse grained, locally graded, gray sandstone with minor granule conglomerate. Locally, interbedded gray siltstone and slate are quite prominent. Quartz, feldspar and minor cherty lithic clasts predominate in the sandstone (litharenite). Some quartz clasts have a blue hue in the poorly sorted granule conglomerate. Sandstone beds vary from 20 cm to 1 m in thickness and locally have 1 to 10 cm thick siltstone tops. The siltstone commonly contains 0.5 to 1 mm laminations. Locally, areas of thinner, interbedded, fine grained sandstone, siltstone and slate occur, *e.g.* west of Third Berry Hill Pond, where beds are 2 to 10 cm thick. Irregular laminations mark the central portions of some of the sandstone beds which grade into regularly laminated siltstone tops. A slaty to phyllitic cleavage or a fine grained schistosity overprints Unit 10, depending upon its spatial relationship to the metamorphic aureole around the Middle Ridge and Third Berry Hill Pond Granites. Biotite porphyroblasts are rare but cordierite and possibly andalusite are profusely developed in a classic fine grained, dark colored, flinty hornfels around the Third Berry Hill Pond Granite.

Unit 10 marks the top of the Davidsville Group in this area (Figure 2). It is interpreted to represent more proximal turbidites, which along Gander Lake are demonstrably conformable with the distal turbidites of Unit 8 (Blackwood, 1980).

UNITS 11 AND 12

The northwest corner of the Great Gull Lake map area is underlain by siltstone, sandstone (Unit 11) and conglomerate (Unit 12). These rocks are along strike with rocks defined as the Silurian Botwood Group (Williams, 1962)

to the northeast (Blackwood, 1981) and are interpreted as possible Silurian (or Upper Ordovician) rocks in this area.

Unit 11 consists mostly of interbedded grayish green siltstone and fine grained sandstone. Beds range from 0.5 to 16 cm in thickness with well developed, regular bedding surfaces. Locally, beds have sandy bases that grade into thicker laminated (1-4 mm) siltstone tops. In some places, massive, medium to coarse grained, gray sandstone occurs. A slaty cleavage is axial planar to tight, recumbent folds. Locally differential movement along cleavage surfaces in the axial zone of these folds produces bedding displacements of a few centimetres.

Unit 12 is a light gray weathering, polymictic conglomerate. Clasts in the conglomerate consist of green and light to dark gray chert, chlorite bearing plagiogranite, grayish black slate and siltstone, gray sandstone, green laminated siltstone, feldspar porphyry, and minor leucogabbro; chert clasts are the most abundant. The poorly sorted clasts are matrix supported, well rounded (some with a high degree of sphericity) and range from 0.5 to 20 cm in diameter; most are pebble size. The matrix is coarse grained and consists of coarse grained, lithic sandstone. A fracture cleavage is locally developed.

MIDDLE RIDGE GRANITE (UNITS 13-15)

The Middle Ridge Granite (Strong *et al.*, 1974) forms a linear pluton that has a northeast-southwest trend throughout both map areas. It gives a whole-rock Rb-Sr isochron age of 370 ± 15 Ma (Bell *et al.*, 1977). The granite is subdivided into three phases based on variations in texture and composition.

Unit 13 consists of medium to coarse grained, crudely equigranular, muscovite-biotite granite that weathers white to pale pink. For the most part the two micas are equally developed. Minor red garnets, 1 to 2 mm in

diameter, occur locally, as do large (0.5 to 4.0 cm across), disoriented biotite phenocrysts. Leucocratic aplite and pegmatite dikes are common.

Unit 14 consists of coarse grained, feldspar porphyritic, muscovite-biotite granite that is also white to pale pink weathering. Feldspar phenocrysts are rectangular to square in shape and range in length from 0.5 to 2.0 cm. They occur as clusters in glomeroporphyritic granite. Locally, the phenocrysts consist of plagioclase crystals which exhibit well developed oscillatory zoning. The relative amounts of muscovite and biotite varies, but the two are everywhere present; rarely, tiny red garnets occur. Leucocratic aplite and pegmatite dikes are common.

Unit 15 consists of white weathering, fine grained to pegmatitic, muscovite-biotite granite. Muscovite generally greatly exceeds biotite and locally biotite is not developed. Garnets are common in the leucogranite and vary from 1 to 5 mm in diameter. Minor tourmaline and beryl occur in parts of the unit. Aplite and pegmatite zones have diffuse boundaries with the fine to medium grained leucogranite.

Aplite and pegmatite dikes of similar composition to Unit 15 occur throughout the Middle Ridge Granite. These dikes range from a few centimetres to one metre in width and generally have regular, sharp contacts with the two-mica granite of Units 13 and 14. The pegmatite consists of quartz, white feldspar (up to 8 cm long) muscovite books (3 to 4 cm across) and garnet (locally up to 2 cm in diameter). Some pegmatite dikes have biotite books and one such dike contains a 10 x 30 cm zone of mostly biotite. Graphic intergrowths and/or myrmekite are common, locally in association with cone shaped masses of finely fibrous sillimanite. Minor tourmaline and beryl occur in both aplite and pegmatite dikes.

A pronounced metamorphic aureole surrounds the Middle Ridge Granite. Mineral isograds representing the appearance of cordierite, biotite, garnet and staurolite porphyroblasts, based on field observations only, are indicated for the Great Gull Lake area. These porphyroblasts overprint the regional foliations in the country rock; locally a strain-slip cleavage in the country rocks appears to form augen around some of them. The isograds west of the pluton are wider spaced than those to the east, indicating a relatively gentler dipping contact for the western margin (also no apophyses of granite occur east of the main pluton, whereas two, the Third Berry Hill Pond Granite and a small plug northeast of Caribou Lake (Blackwood, 1981), occur in the west.

The Middle Ridge Granite is weakly foliated to unfoliated, generally by a L-S fabric defined by partially oriented mica. In a few localities where the fabric is most pronounced, there is minor flattening of quartz in the foliation planes. The mica orientation generally dips gently to the east or west, towards the nearest margin, and parallels the granite contacts. Locally, a steep orientation occurs right at the contact and flat attitudes are measurable away from the contacts. This foliation is interpreted to be related to the intrusion of the Middle Ridge Granite such that it broadly conforms to the attitude of the granite/country rock boundaries. Thus, the gentle to flat mica orientations that occur within the granite would suggest that the exposed part of the pluton represents the top of the intrusion. The rafts in the Dead Wolf Pond area and in the Great Gull Lake area are probably roof pendants.

THIRD BERRY HILL POND GRANITE (UNITS 16 AND 17)

The Third Berry Hill Pond Granite is a small circular body that occurs west of the Middle Ridge Granite and is interpreted to be an apophysis of the

larger pluton. Although granite outcrop is rare, the intrusion can be delineated by the profusion of white weathering boulder heaps. The granite is subdivided into two phases based on texture and composition.

Unit 16 consists of coarse grained, feldspar porphyritic, biotite granite. Feldspar phenocrysts range from 0.5 to 2 cm in length. Muscovite was not observed in hand specimen. The granite is unfoliated.

Unit 17 consists of fine to medium grained, muscovite greater than biotite, granite. Locally, the granite is porphyritic with globular, translucent, quartz phenocrysts that range from 4 to 7 mm in diameter and rectangular plagioclase phenocrysts that are up to 1.5 cm in length. Biotite is a minor component and rarely, fine grained biotite is concentrated in patches. Tiny red garnets are common. In one area, granite boulders contain vugs lined with blue, white and red botryoidal chalcedony. No foliation was observed.

CORRELATIONS OF UNITS TO THE SOUTH AND WEST

The geology of the Mount Sylvester (2D/3) map area to the south of Great Gull Lake (2D/6) was compiled by Swinden and Dickson (1981). Ultramafic rocks in that area (Unit 1) form an elliptical zone and occur along strike with ultramafic rocks (Unit 1) in the Great Gull Lake area. Arkose and psammite (Unit 2) of the Gander Group correlate with similar rocks (Unit 9) defined as part of the Baie d'Espoir Group (Jewell, 1939) to the south. These rocks are restricted to the northeastern corner of the Mount Sylvester map area and are interpreted by Swinden and Dickson (1981) and this writer to represent the southwestward termination of the Gander Group. Quartz-feldspar porphyry (Unit 4) in the Middle Ridge Pond area continues throughout the Mount Sylvester map area (Unit 10) where it is defined as part of the Twillick Brook Member (Colman-Sadd,

1980a). Units 3, 5, 6, 8, and 10 in the Great Gull Lake map area continue or pinch out in undivided sedimentary and minor volcanic rocks (Unit 2) in the Mount Sylvester map area. No outcrops of the Middle Ridge Granite occur in the boundary area of these two map areas. For this reason it is not indicated on the Mount Sylvester map, although Anderson and Williams (1970) assumed it terminated just south of that map's northern boundary.

The Great Gull Lake (2D/6) map area adjoins the Burnt Hill (2D/5) map area (Colman-Sadd, 1980b) to the west. Sandstone, siltstone and slate (Unit 10) which form the upper part of the Davidsville Group continue southwestward where they are defined as the North Steady Pond Formation (Unit 9) of the Baie d'Espoir Group. Felsic volcanic rocks (Unit 11a) in the Burnt Hill area are not exposed in the Great Gull Lake area and are interpreted by Colman-Sadd (personal communication, 1981) to pinch out near the boundary between the two map areas, possibly just northwest of Little Gull Lake. Rocks designated as Ordovician or Silurian (Units 11 and 12) in the northwest corner of the Great Gull Lake map area are indicated as Ordovician Baie d'Espoir Group in the Burnt Hill area. The assumed contact between Units 10 and 11 (2D/6) extends into a poorly exposed area of Unit 9a (2D/5). Conglomerate of Unit 12 (2D/6) correlates well with conglomerates of Unit 10 (2D/5). The local mismatch in contacts is due to the poor exposure in this area and contrasting interpretations on the age of rocks. They are indicated as possible Silurian age in the Great Gull Lake map area because they are along strike with a belt of dated Silurian rocks (Anderson and Williams, 1970; Blackwood, 1979, 1980, 1981) and because the conglomerates of Unit 11 contrast sharply with re-sedimented conglomerates noted elsewhere in the Middle Ordovician Davidsville Group. Unit 11 is, however, quite similar to conglomerates that occur along strike in association with

the Silurian Botwood Group and are possible correlatives of the Upper Ordovician - Lower Silurian Goldson Formation (Twenhofel and Shrock, 1937).

MINERALIZATION

Beryl was found in a few localities in the Middle Ridge Granite. These showings are in the more evolved leucocratic phase of the granite (Unit 15) or in nearby dikes of the same material. The beryl occurs as small aquamarine crystals that range from 0.2 to 0.7 mm in cross-section. One occurrence of molybdenite was found in a pegmatite intruding two-mica granite (Unit 13) near Little Gander Pond. The molybdenite forms 0.5 to 2 cm tabular crystals in two or three places in the pegmatite. Molybdenite was also reported (Howse, 1936) in granite boulders from the Third Berry Hill Pond Granite. It occurred in 5 to 7 cm wide quartz veins and as fine disseminations in granite adjacent to the veins.

A variety of mineralization is associated with leucocratic granite veins that intrude sandstone and siltstone of Unit 10, south of Berry Hill Pond; these veins are probably related to the Middle Ridge Granite. The showings are located in a rock quarry on the east side of the Bay d'Espoir Highway. The granite veins consist of quartz, plagioclase, microcline and muscovite and vary from 2 to 25 cm in width. They also appear greisenized, *i.e.*, some of the mica is greenish-yellow in color and may be lepidolite; calcite and small flecks of purple fluorite occur locally. Scheelite forms grayish-white patches in the veins and fluoresces a bright blue. Euhedral crystals and small patches of pyrite, pyrrhotite and minor arsenopyrite also occur. The margins of the dikes are locally muscovite rich with the mica forming 0.5 to 1 cm wide rims. Two to thirty centimetre wide alteration zones, rich in muscovite and containing euhedral crystals of pyrite and pyrrhotite, occur in the sediments

adjacent to the granite veins. These zones also contain narrow, 2 to 6 mm wide veins of gray fibrous anthophyllite.

The economic potential of the map areas mostly centers around the following rock units:

(1) Volcanic and related rocks in the Middle Ridge Pond - Newton Lake area. The quartz-feldspar porphyry (Unit 4) is probably subvolcanic to extrusive and is continuous with the Twillick Brook Member (Colman-Sadd, 1980a). It represents subaqueous felsic volcanic activity, with associated conglomerates and tuffs that could host base metal deposits.

(2) Ultramafic rocks localized along faults. These rocks (Unit 1) are interpreted as remobilized and altered fragments of oceanic crust that were emplaced along faults during the Acadian Orogeny. Thus, they have potential for gold, nickel, and other ophiolite related mineralization.

(3) The Middle Ridge Granite. Greisen zones in the granite and related dikes are a good target for tin and tungsten mineralization. These may follow the more evolved phase of the pluton (Unit 15).

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GENERAL GEOLOGY AND REGIONAL SIGNIFICANCE OF THE GRANDYS LAKE AREA

(110/15), NEWFOUNDLAND

by

Lesley Chorlton

INTRODUCTION

New information provided during the recent mapping project (Chorlton, 1978, 1980a, 1980b, 1980c; Dallmeyer, 1979; Chorlton and Dingwell, 1981) has led to a re-evaluation of the significance of southwestern Newfoundland in the plate tectonic development of the Newfoundland Appalachians. A preliminary attempt is made here to define geological components in southwestern Newfoundland, especially in the Grandys Lake area, and to assess them in the context of the revised regional model.

The Cape Ray Fault, which traverses diagonally across the Grandys Lake area, was previously considered a cryptic suture juxtaposing two Precambrian continental basement complexes, the 'Long Range Gneiss' and the 'Port aux Basques Gneiss' (Brown, 1973). The axial region of the Central Mobile Belt (Williams, 1964), a zone characterized by Early Paleozoic oceanic crust overlain by island arc and marine sedimentary sequences, was thought to be pinched out along this fault to the northeast of the area (Kennedy, 1976; Brown and Colman-Sadd, 1976).

Recent work in the La Poile (110/9) and La Poile River (110/16) map areas challenges this interpretation, and has revealed that the area southeast of the Cape Ray Fault in those areas is underlain by an Ordovician metavolcanic pile with island arc affinities grading laterally into a probable marine meta-sedimentary sequence with associated amphibolite. These rock assemblages are presently assigned to the Bay du Nord Group (Cooper, 1954; modified by Chorlton, 1980b) and the time equivalent

La Poile Group (Cooper, 1954; redefined by Chorlton, 1978). The metasedimentary rocks and associated amphibolite continue westwards into the Grandys Lake (110/15) map area, and can be correlated with the 'Port aux Basques Gneiss' of Brown (1975), previously considered Precambrian continental basement. Pre-volcanic mafic plutonic rocks, especially those underlying the Blue Hills of Couteau southeast of the Cape Ray Fault (Chorlton, 1980a), are partly composed of ophiolitic high level gabbros (G.R. Dunning, personal communication, 1981), representing segments of Lower Paleozoic oceanic crust. North of the Cape Ray Fault in the Grandys Lake area, ophiolitic rocks of the Lower Paleozoic Long Range Mafic-Ultramafic Complex (Brown, 1976) are now also interpreted as the oldest rocks exposed. Therefore, the Cape Ray Fault can no longer be referred to as a cryptic suture between two continental basement terranes. Rocks typical of the axial region of the Central Mobile Belt, although more highly deformed and metamorphosed, actually underlie much of the Grandys Lake area on both sides of the fault. However, lithologies now exposed on either side contrast somewhat. In plate tectonic jargon, the northwestern terrane might be the ophiolite-based, plutonically intruded basement to either part of a 'subduction complex' or a 'forearc basin' (cf. Dickinson, 1977; Seely *et al.*, 1974, Hussong and Uyeda, 1981), and the southeastern terrane a sedimentary 'forearc basin' underlain by largely mafic rocks (Figures 1 and 2, Table 1). Both terranes are part of an 'arc-trench system', the volcanic 'arc' of which is represented by the Bay du Nord-La Poile Group volcanic centre exposed southeast

Figure 1 Suggested relationships among pre-tectonic lithostratigraphic units (1, 2, 3, on map) in southwest Newfoundland before collision of arc trench gap with North American continent

- 1A Model reflecting early block faulting and subsidence in arc trench gap
1B Model reflecting imbrication above subduction zone

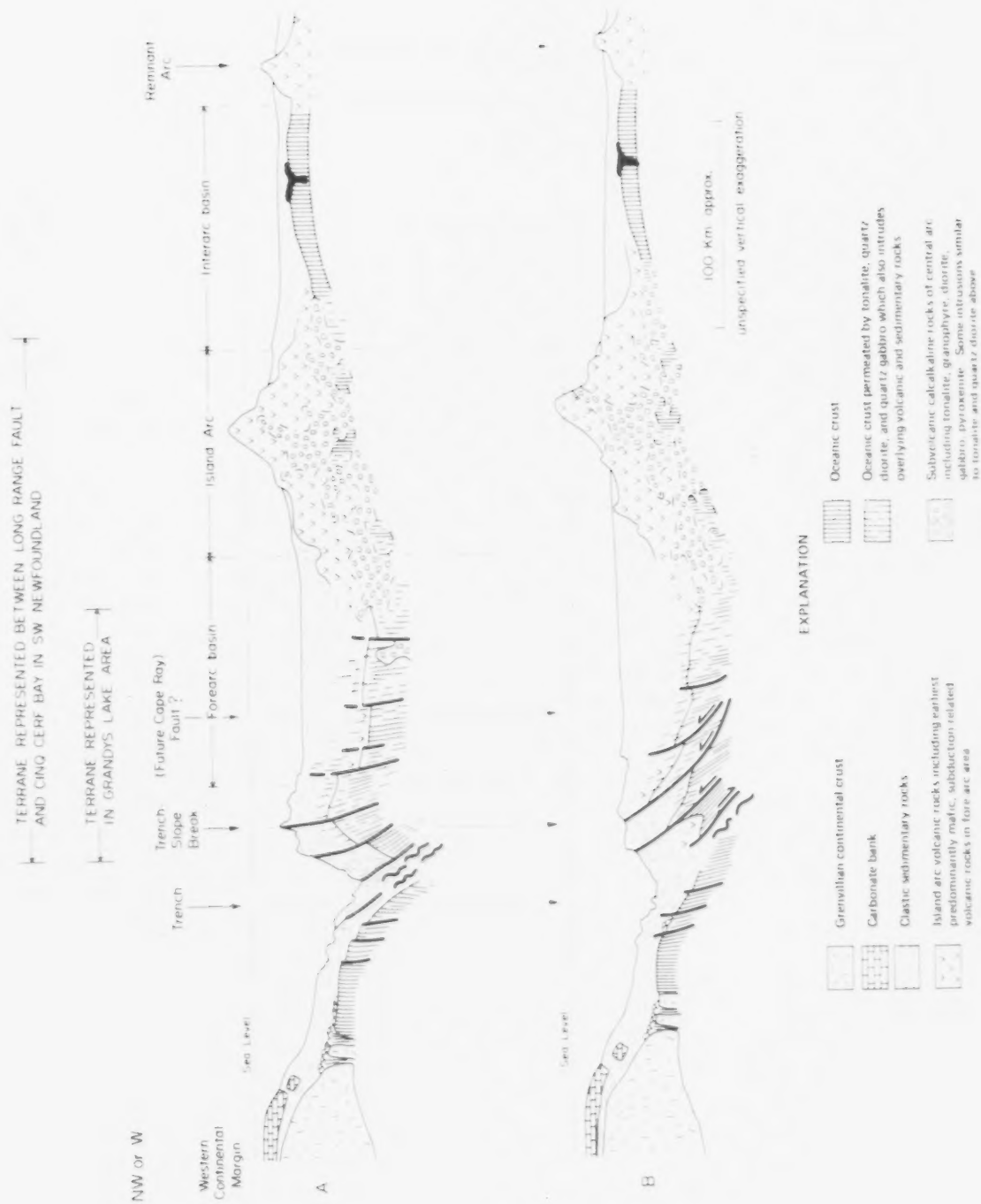
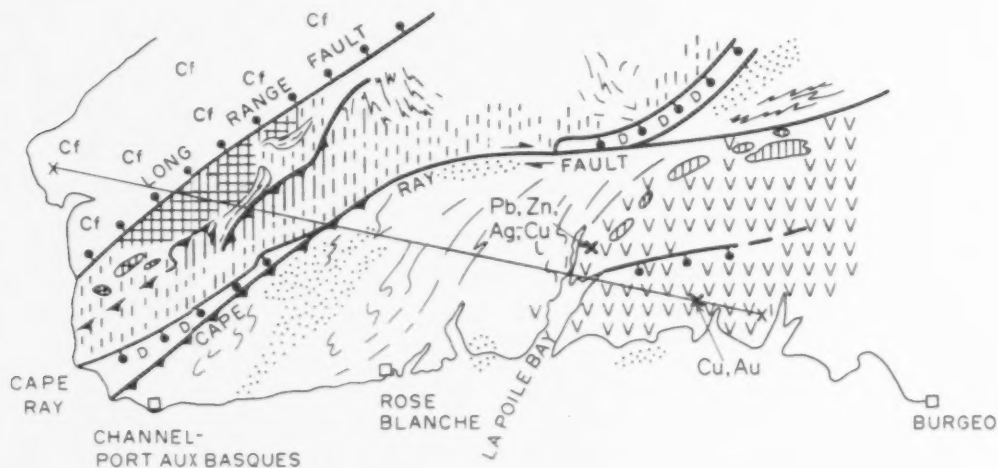
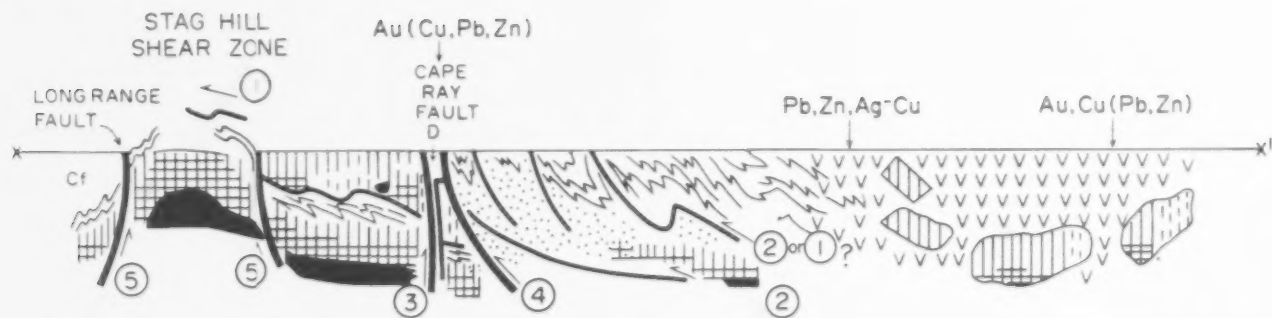


Figure 2: Approximate distribution of ophiolitic rocks and derivative amphibolite, and Ordovician metasedimentary and island arc metavolcanic, subvolcanic, and volcanoclastic rocks in southwest Newfoundland.

a



b. scale expanded from a



EXPLANATION

Carboniferous sedimentary rocks Cf

Devonian volcanic and sedimentary rocks DDD

Ordovician metasedimentary rocks, structural trends indicated

Ordovician island arc metavolcanic, subvolcanic, and volcanoclastic rocks V V

Fault, movement and relative stage indicated (4)

Thrust fault (may have sited later movement)

Block fault

OPHIOLITIC ROCKS

High level gabbro, diabase, basalt

High level gabbro, diabase, basalt, engulfed by tonalite

Layered, cumulate Ol-bearing metagabbro

Massive ultramafic rocks

Amphibolite of probably ophiolitic origin

of the Grandys Lake map area.

GENERAL GEOLOGY

The effects of early regional deformation and metamorphism are presently the most convenient frame of reference for outlining the geological history of this area. Therefore, these effects have here been used to separate the geological development into three stages prior to Carboniferous sedimentation in the Codroy Valley to the west. However, it is emphasized that the sequence of tectonic events was not necessarily synchronous across the entire area. Present tectonic models for the Newfoundland Appalachians involve southeasterly-dipping subduction followed by the northwesterly-directed thrusting which finally resulted in ophiolite obduction. According to these models, the earliest effects of obduction-related compressive deformation is envisaged as progressively younger toward the southeast (Table 1). It is conceivable that the early stages of thrusting in the northwest may have overlapped with the latest stages of deposition in the forearc and arc areas to the southeast (*i.e.* Figure 1b). The earliest deformation recorded in rocks exposed on the south side of the Cape Ray Fault affected the radiometrically dated Middle(?) Ordovician volcanic rocks southeast of the map area.

STAGE 1

The first stage involved the generation of the oldest rocks in the area, the ophiolitic Long Range Mafic-Ultramafic Complex (1a,b,c,d,e, part of 3b) and the deposition of overlying sedimentary rocks. The sedimentary rocks in the northwest consisted of graywacke, shale, limestone, marl, quartzitic sandstone, ferruginous chert, tuffaceous and possibly other volcanic-related rocks (2a,b,c), which are now highly metamorphosed. Mafic metavolcanic rocks (1d) are also associated with these

metasedimentary rocks. A sequence of graywacke and shale (3a) with minor interbedded basalt (part of 3b) in the southeast, belonging to the modified Bay du Nord Group (tentatively retained name), may have postdated the deposition of some of the rocks of unit 2 and overlapped in time with stage 2 in the northwest.

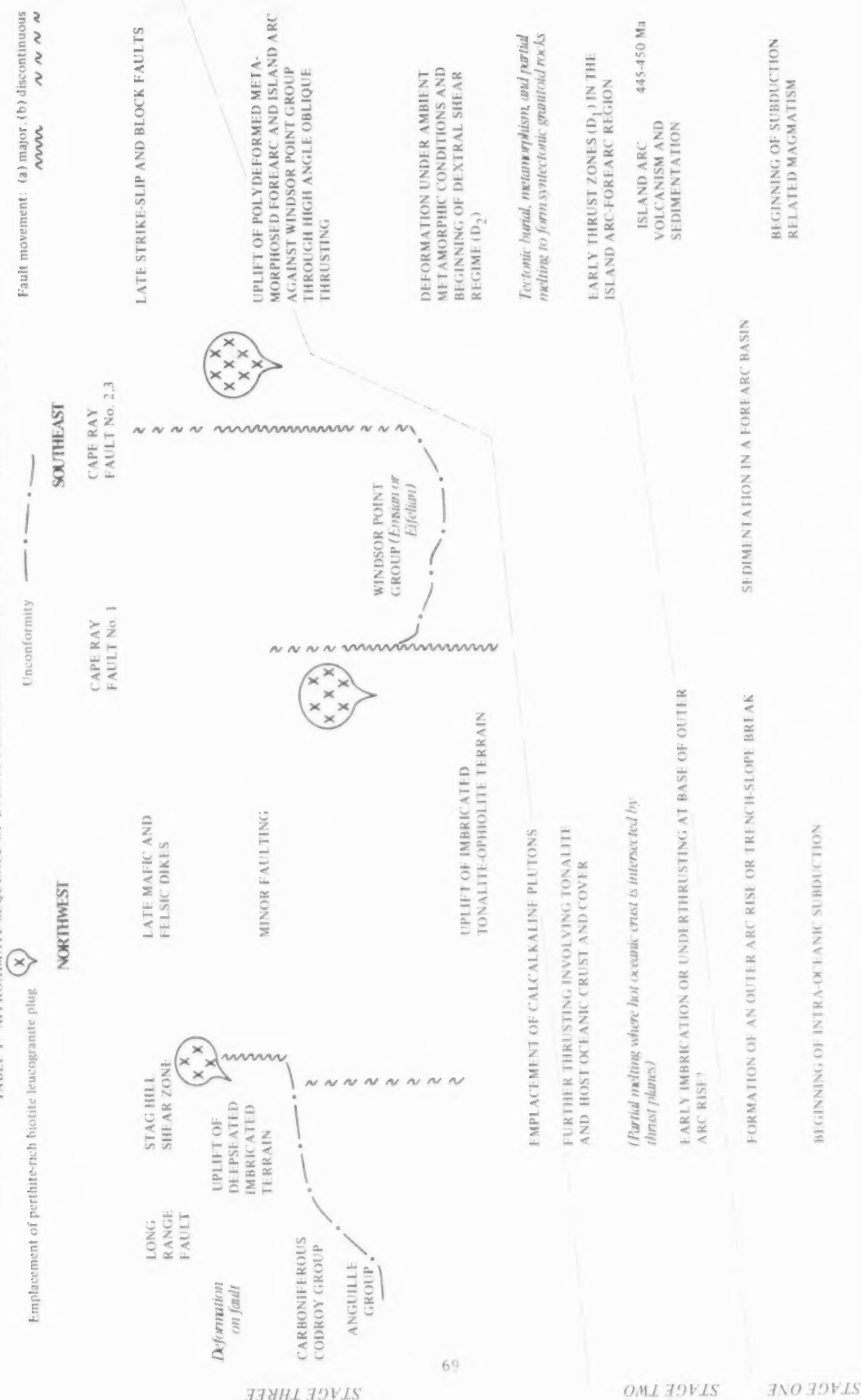
STAGE 2

The second stage involved early, intense, polyphase regional deformation which accompanied westerly or northwesterly directed imbrication and thrusting (Figure 2b, fault movements 1 and 2):

In the northwest, the lower parts of the ophiolitic crust were locally intersected by thrust planes (Figure 2b, fault movement 1). These rocks, which may have initiated their deformation history at high temperatures, presumably became partially hydrated during thrusting. Consequently, they would have been either retrograded or partially melted depending on whether the temperature maintained was lower or higher than the solidus (beginning of partial melting) temperature. Partial melting would explain the presence of the voluminous tonalite (4) and later magmas that intruded the ophiolitic rocks and their cover. Megacrystic quartz monzonite (6) succeeded these early granitoid rocks. These intrusions and their hosts were penetratively deformed and metamorphosed. Further imbrication and repetition of localized thrusting may have caused the superposition of a dynamothermal aureole in the tonalite and its inclusions (4b,2c,1d) sited within a shear zone underneath the thrust sole (now eroded) in the north-central part of the map area.

In the southeast, early thrusting (Figure 2b, fault movement 2 and/or 1?) resulted in tectonic burial and metamorphism, accompanied by local migmatization and sheetlike emplacement

TABLE 1. APPROXIMATE SEQUENCE OF EVENTS FROM NORTHWEST TO SOUTHEAST IN SOUTHWEST NEWFOUNDLAND



LEGEND

CARBONIFEROUS

- 12 Sedimentary rocks, largely alluvial fan deposits of the Codroy Group.

DEVONIAN OR YOUNGER

- 11 Late mafic and felsic dikes (many not shown)
- 10 Pink, perthite-rich biotite leucogranite plutons with hypersolvus and subsolvus phases.
- 9 Pink, largely fine but locally medium grained, two feldspar leucogranite, local tuffisite.

DEVONIAN

- 8 WINDSOR POINT GROUP: Strongly bimodal volcanic and volcanoclastic rocks with associated sedimentary rocks.
- 7 Quartz diorite to megacrystic granite with many tonalite and amphibolite screens.

SILURIAN

- 6 Deformed, megacrystic quartz monzonite, locally augen gneiss, minor megacryst poor patches.
- 5 ROSE BLANCHE GRANITE: Schistose to gneissic tonalite, granodiorite, granite with many country rock screens.

ORDOVICIAN and possibly older

- 4 Foliated tonalite, granodiorite and granite with abundant rafts, inclusions, or country rock screens; 4a, biotite tonalite to trondhjemite; 4b, inclusion-rich, foliated to gneissic garnetiferous biotite tonalite; 4c, garnetiferous biotite granodiorite to tonalite, gneissic lit par lit injections and sheets; 4d, pink, foliated to gneissic granite.
- 3 Modified BAY DU NORD GROUP: 3a, Mainly semipelitic schist, migmatite; 3b, amphibolite.
- 2 Metasedimentary rocks: 2a, Largely semipelitic paragneiss, migmatite; 2b, marble; 2c, assorted metasedimentary xenoliths.
- 1 LONG RANGE MAFIC-ULTRAMAFIC COMPLEX: 1a, ultramafic rocks; 1b, layered cumulate metagabbro; 1c, massive, vari-textured metagabbro, metadiabase, and plagiogranite; 1d, mafic metavolcanic rocks and dikes; 1e, undivided amphibolite.

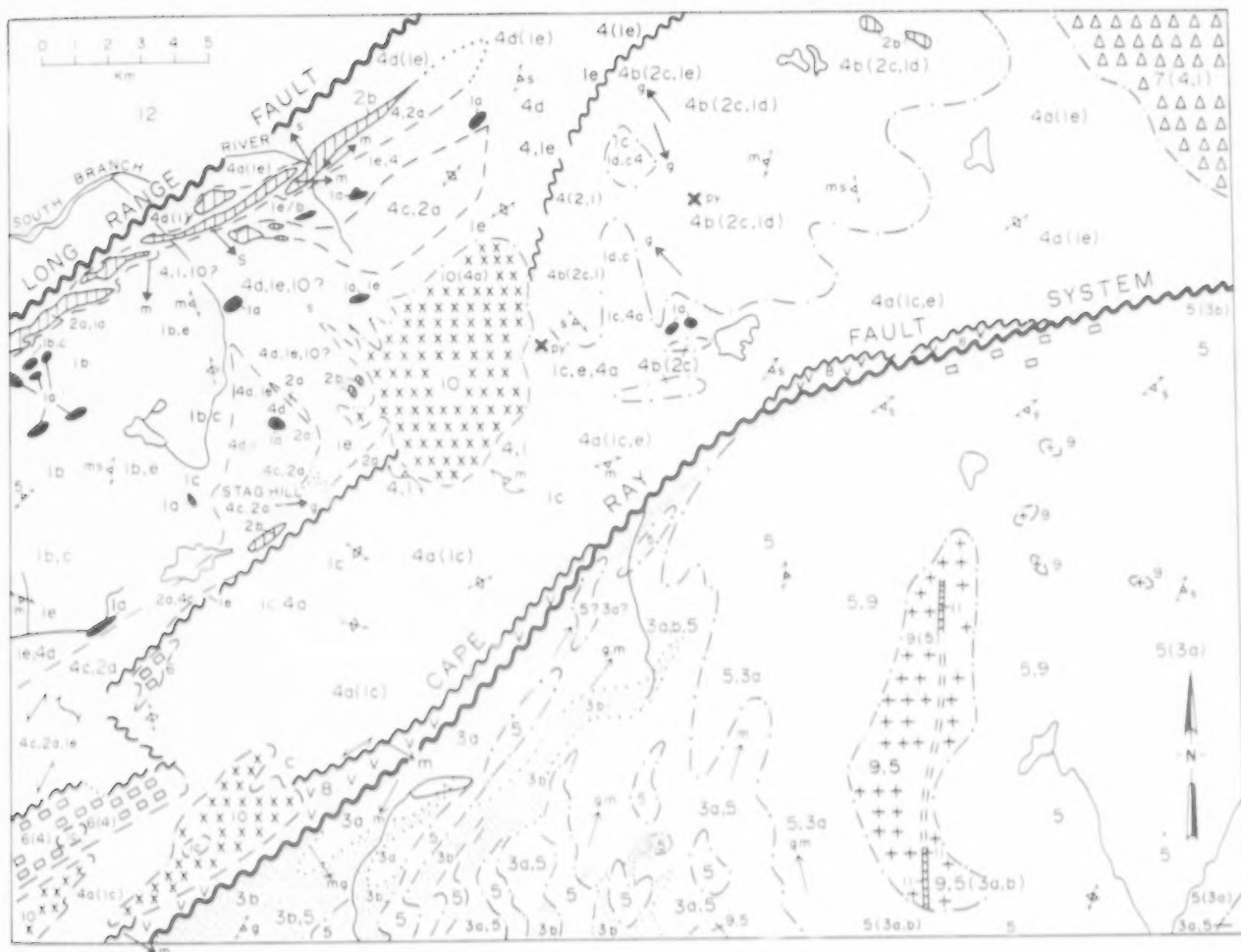


FIG. 3 GRANDYS LAKE II-O/15

of the Rose Blanche Granite (5). The thickest granitoid units were probably generated slightly deeper in the metamorphic pile. After emplacement, these granitoid rocks were moderately to intensely deformed under the prevailing metamorphic conditions.

STAGE 3

The third stage initially involved the emplacement of a quartz diorite-megacrystic granite intrusion (7), which postdated the penetrative deformation of the early granitoid rocks (4) in the north. Subsequent uplift of the northwest part of the Grandys Lake area along the Cape Ray Fault system (Figure 2b, fault movement 3), and either sinistral or dextral strike-slip movement along the fault, was accompanied or followed by the eruption and deposition of strongly bimodal volcanic and associated sedimentary rocks of the Windsor Point Group (8). Subsequently, the Bay du Nord Group (3) and Rose Blanche Granite (5) were uplifted obliquely against the Windsor Point Group along the fault zone and the tonalite-ophiolite terrane north of the fault by northwesterly directed, high angle thrusting (Figure 2b, fault movement 4). This was followed by, or possibly accompanied, the emplacement of the late leucogranite plutons (9, 10) and mafic and felsic dikes (11).

CARBONIFEROUS

The Carboniferous sedimentary rocks northwest of the Long Range Fault belong to the Anguille Group (Tournaisian?, possibly older), the Codroy Group (Middle to Upper Visean), and the Barachois Group (Westphalian A) (Baird and Cote, 1964). The Codroy and Barachois Groups were deposited after emplacement of the youngest plutonic rocks in the terrane southeast of the Long Range Fault, but it is possible that the Anguille Group was deposited before the cessation of plutonism. Uplift of a strip of the pre-Carboniferous ophiolitic terrane along the

present Long Range Fault affected the adjacent Carboniferous rocks (Figure 2b, fault movement 5). This activity may have been accompanied by dextral strike-slip movement and block faulting on smaller, reactivated faults and shear zones.

SUMMARY

The geological development of the Grandys Lake and surrounding areas reflects the evolution of the proto-Atlantic Ocean from the earliest stages of intra-oceanic closure to cratonization of the oceanic terrane (and inferred collision of an arc-trench gap with the North American continent). Primarily oceanic crust rapidly attained a continental character by means of subduction-related island arc volcanism and plutonism which evolved into syntectonic/metamorphic granitoid emplacement. This was followed by block and wrench fault activity, the formation of Devonian fault-controlled sedimentary basins and bimodal volcanic activity, and late stage granite emplacement.

Easterly or southeasterly-directed subduction began to the west or northwest of the terrane represented in this area, and resulted in the development of the Central Newfoundland island arc system. Rocks belonging to one of the volcanic centres of the arc are exposed southeast of the area near La Poile Bay. An 'outer arc' rise in the northwest may have resulted in the formation of a forearc sedimentary basin in front of the volcanic arc. The forearc sedimentary sequence contains interbedded mafic volcanic rocks. In the northwest part of the area, early imbrication and underthrusting of oceanic crust and its sedimentary cover, either within the upper slab or in an accretionary wedge, may have been accompanied by the generation of synmetamorphic tonalite within the thrust complex, perhaps while the last stages of sedimentation and island arc activity continued in the southeast.

Upon complete and final collision with the North American continental margin, ophiolite imbrication continued (or began) in the northwest, and thrusting to the west or northwest affected the forearc and arc terrane in the southeast. This caused tectonic burial and associated medium pressure, medium to high grade regional metamorphism, accompanied by the generation of synkinematic granodiorite and tonalite in the forearc and arc areas. Further deformation under amphibolite facies conditions in this terrane apparently reflects the beginning of a sinistral or dextral ductile shear system. In the northwest part of the area, a megacrystic quartz monzonite and calc-alkaline diorite/ granite body was emplaced before uplift of parts of the northwestern terrane along the Cape Ray Fault.

The eruption and deposition of bimodal volcanic and sedimentary rocks of the Windsor Point Group occurred within an 'intracratonic' basin controlled by block and wrench faulting along the initial Cape Ray Fault. Deposition was halted by oblique, high angle thrusting of the older, deformed rocks in the southeast against the Windsor Point Group along the southeast side of the Cape Ray Fault, and continued strike-slip movement. Potassic granite plugs and mafic and felsic dike swarms signify the last stages of magmatic activity.

Carboniferous sedimentation largely postdated this activity. However, the initiation of the oldest parts of the sedimentary basin associated with the base of the Anguille Group may have coincided with movement on the Cape Ray Fault system (Knight, in preparation). The Carboniferous rocks were affected by late uplift along the Long Range Fault, and by continued stress resolved by minor folding and faulting.

MINERAL POTENTIAL

Of three established mineral

prospects in southwest Newfoundland (Figure 2), two are sited in the Middle(?) Ordovician island arc southeast of the Grandys Lake area. The third, a gold prospect, is located in the Cape Ray Fault zone at the southwest corner of the Grandys Lake area.

The Strickland Prospect (massive Pb-Zn-Ag and disseminated Cu) formed in a marine environment near the northwestern margin of the Middle Ordovician volcanosedimentary pile at the edge of a small starved marine trough, and in the vicinity of a subvolcanic granitoid stock and dike system. It has been described in detail by Cooper (1940a, 1940b, 1954), Swinden (1981), and others. The sulphides are associated with felsic volcanic bands interlayered with largely volcanoclastic rocks. The trough is characterized by graphitic phyllite with tuffaceous graywacke schist and volcanic-derived granule conglomerate interbeds. The showings and their hosts are poly-deformed and metamorphosed to lower amphibolite or upper greenschist facies, further sheared and partly retrogressed. Since they were discovered in 1935, the Strickland Prospect and several showings in the same volcanic horizon have been the focus of recurrent regional exploration and mineral assessment, most recently by Falconbridge Nickel Mines Ltd.

The Chetwynd Prospect (Cu-Au) occurs in a more massive, either shallow marine or subaerial, part of the volcanic edifice to the southeast. Best accounts of the mineralization are by Cooper (1940b, 1954), Poullot (1957), and Swinden (1981). Disseminated and vein type mineralization is sited in one of two highly sheared and altered felsite bands which may have originated either as extrusive rhyolite (ash?) flows or as subvolcanic rhyolite dikes or sills. The surrounding volcanic terrane comprises mafic to intermediate flows, tuffs, hypabyssal rocks, and felsic tuffs, north of which a prominent conglomeratic sedimentary horizon is

exposed. All are now deformed and metamorphosed under greenschist facies conditions. Three shallow shafts were sunk in and adjacent to the northernmost, cupriferous felsite band between 1903 and 1905 (Cooper, 1940b). A shallow trench was later cut across the most productive zone. Pyrite, chalcopyrite, tennantite, bornite, chalcocite, covellite, malachite, barite, fluorite, and pyrophyllite occur in the mine dump and around the collar of the main shaft. The fee simple grant which encloses the area of the shafts was recently declared undeveloped by the Government of Newfoundland and Labrador, and will soon be open for staking.

The Cape Ray gold prospect consists of several showings of gold associated with base metal sulphides, and was described by Bucknell *et al.* (1980). In general, the showings are vein occurrences sited in (i) the highly sheared Windsor Point Group and/or in mylonitized Bay du Nord amphibolitic gneisses which occur along a shear zone of the Cape Ray Fault system, and (ii) in the Windowglass Hill Granite adjacent to the southwest corner of the Grandys Lake area. The Windowglass Hill Granite is considered a subvolcanic granophyre or rhyolite dome, genetically related to the strongly bimodal volcanic rocks of the Windsor Point Group. Significant factors relating to the mineralization may be: (1) the favourable precipitation environments offered by the Devonian volcanic and metasedimentary (locally graphitic) rocks of the Windsor Point Group (Bucknell *et al.*, 1980), (2) the oceanic to subduction related affinities of the underlying ophiolite-founded arc-trench gap traversed by the Cape Ray Fault, and (3) hydrothermal activity associated with the fault system. The Cape Ray property, part of a mineral concession granted to Brinex, has been the object of intensive exploration and assessment by Riocanex Ltd. (Northern Miner, 1977, 1978, 1980).

Recent re-interpretation of the geology of southwest Newfoundland

suggests a greater mineral potential for this area than previously envisaged. Cyprus type massive sulphide (Fe-Cu) deposits (Hutchinson, 1973, 1980; Strong, 1974) are potentially present in hypabyssal and extrusive mafic volcanic parts of the ophiolite *i.e.*, massive metagabbro and metadiabase (1c) to mafic metavolcanic and metasedimentary rocks (1d,e, 2c). Besshi or keislager type massive sulphides (Cu-Zn?) are also potentially associated with graywackes and mafic volcanic rocks in arch-trench gaps (Sawkins, 1976; Hutchinson, 1980), and could conceivably be hosted by metasedimentary rocks and interlayered amphibolites of the forearc basin, *i.e.*, the modified Bay du Nord Group (3a,b) or the metasedimentary and associated metavolcanic rocks (2,1d,1e) northwest of the Cape Ray Fault. Alternatively, early arc volcanics, potentially hosting the 'volcanogenic primitive type' (Zn-Cu) massive sulphides (Hutchinson; 1980), could also be considered possible analogues for the mafic metavolcanic rocks in either of the above units, since their affinities have not been investigated. Massive sulphide occurrences could conceivably be responsible for highly sheared, altered sulphide showings (Figure 3) where tonalite-intruded, high level gabbro and metadiabase (4a,1c) switches abruptly to tonalite-intruded, metasedimentary and mafic metavolcanic rocks (4b,2c,1d). Any massive sulphide mineralization in this region may have been affected by magmatic recycling during the generation of abundant late granitoid rocks and possibly selectively remobilized or concentrated by hydrothermal activity along several generations of shear zones which characterize the area.

Northwest of the Cape Ray Fault, several quartz diorite to quartz monzonite and granite plutons may have potential for porphyry copper mineralization (*cf.* Strong, 1980). The age of these plutons is uncertain, but they could range from Middle Ordovician to Early Devonian based on field relations. One such pluton (7) in the

northeast corner of the Grandys Lake area shows evidence for late magmatic hydrothermal alteration accompanied by orthoclase porphyroblast development. Several similar, post-tonalite, pre-Windsor Point Group, granitoid plutons, some with minor mineralization, have been observed in the northwestern terrane northeast of the Grandys Lake area (Herd and Dunning, 1979; Kean and Jayasinghe 1980; G.R. Dunning, personal communication, 1981) and southwest of the area (D. Wilton and C.B. Mackenzie, personal communication, 1979). This suite may therefore be common in the northwestern terrane, and might be intersected at the present erosion surface at higher emplacement levels elsewhere, since the Devonian vertical movements cannot be expected to have affected the whole terrane homogeneously. Granitoid-hosted porphyry mineralization is known in similar settings elsewhere in the Appalachian system (Hollister *et al.*, 1974). Evidence of hydrothermal activity, ranging in age from that associated with the early thrust zones (Ordovician) to that associated with the Cape Ray Fault and other late structures (Devonian), is common in this terrane. Hydrothermal activity which encountered coeval mineralized granitoid rocks may have produced significant mineral enrichment.

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THE PRE-CARBONIFEROUS GEOLOGY OF SOUTHWEST WHITE BAY

by

W.R. Smyth and H. Scott Schillereff

INTRODUCTION

The study area lies on the eastern side of the Long Range Grenville inlier in western Newfoundland. Autochthonous, Lower Paleozoic, clastic-carbonate rocks unconformably overlie the basement and dip steeply eastwards away from it. Structurally overlying the autochthon are a number of thrust sheets composed of graywacke, greenschist, ultramafic rocks and melange, and a pre-Silurian igneous complex that consists dominantly of tonalite. The thrust sheets are here collectively referred to as the Southern White Bay Allochthon, which is interpreted as a Taconic allochthon. A Silurian cover sequence, the Sops Arm Group, of dominantly subaerial, felsic volcanic rocks, coarse clastics and shallow marine sedimentary rocks locally unconformably overlies part of the allochthon, but in most places is in thrust contact or tectonically imbricated with it by Acadian orogenesis. A Siluro-Devonian igneous suite of granodiorite, gabbro and granite informally named the Gull Lake intrusive suite intrudes the Sops Arm Group. Carboniferous clastic rocks complete the sedimentary record and were deposited apparently in two separate basins in the south of the area on either side of the northeast trending intrusive suite. Hercynian thrusting locally juxtaposed the Sops Arm Group and part of the Allochthon on top of the Carboniferous rocks.

The Sops Arm Group hosts a number of gold and base metal occurrences and the Gull Lake intrusive suite hosts fluorite, molybdenite and pyrite mineralization.

A review of previous work in the area and a background to this project is given in Smyth (1981). The area was

remapped in 1981 on 1:50,000 scale and preliminary 1:25,000 scale geological field maps of the area were recently released on open file (Smyth and Schillereff, 1981). The final map will be published at 1:50,000 scale.

GRENVILLE BASEMENT (UNIT 1)

The Grenville inlier is underlain by quartzofeldspathic gneiss, augen granite gneiss, amphibolite, anorthosite, gabbro and granite (Unit 1), collectively referred to as the Long Range Complex. It was not mapped in this study. The only information available on the southern part of the inlier is a reconnaissance map of Baird (1960). Access to the inlier, however, is good; the coast and fiords offer 100% exposure and the new Cat Arm access road now offers easy access to the inland plateau (Map 1).

DEVILS ROOM GRANITE (UNIT 2)

The Devils Room granite is an informal name applied by Lock (1969a) for a triangular shaped, posttectonic granite that intrudes the gneisses of the Long Range Complex west of Sops Arm (Map 1). Heyl (1937) and Lock (1969a, b) considered this granite to be Paleozoic in age and to be a part of the Gull Lake intrusive suite that was displaced 15 km northwards along a right lateral fault. Both the Devils Room granite and the Gull Lake intrusive suite were mapped and sampled for lithogeochemistry in the study to test this hypothesis. Mapping of the Devils Room granite was carried out by W. Dunford and the following is a summary of a report by him (Dunford, 1981).

The granite occurs in a series of shallow, inward dipping sheets. There is a variation in composition, texture and

grain size from the margin to core and four subphases, three with gradational contacts, were delineated. The southeastern margin is a fault with the Coney Arm Group. The northern margin is marked by a strong lineament, here interpreted as a fault, but considered by Dunford as an intrusive contact. The southwestern contact was not located on the ground and is probably intrusive.

FELSITE (SUBUNIT 2A)

A narrow band of pink felsite borders the northern margin of the pluton. It is mostly massive but includes weakly foliated varieties. It consists of a fine aggregate of quartz + K-feldspar + muscovite. No contacts were seen and the rock is either a dike into Subunit 2b or the chilled margin of the pluton.

MEGACRYSTIC K-FELDSPAR, BIOTITE GRANITE (SUBUNIT 2B)

The wide, outer zone of the pluton is characterized by K-feldspar megacrysts up to 10 cm across in a medium grained, red groundmass of quartz feldspar and biotite. Narrow felsite or aplite dikes were observed around the western margin.

PORPHYRITIC BIOTITE GRANITE (SUBUNIT 2C)

A red to pink to white, K-feldspar porphyritic biotite granite forms the next zone of the pluton. It consists of scattered feldspar phenocrysts up to 4 cm across in a medium to fine grained groundmass. Gradational contacts exist with Subunits 2b and 2d.

MEDIUMGRAINED, BIOTITE + MUSCOVITE GRANITE (SUBUNIT 2D)

A medium grained, pink to white, biotite + muscovite granite occupies the central part of the pluton. Contacts with Unit 2c are gradational. It has a medium to fine grained groundmass with scattered quartz and feldspar phenocrysts.

DISCUSSION

Alignment of phenocrysts was rarely observed in the outer two zones (2b and 2c) and the inner zone is massive. The inward dipping sheeting, although grossly paralleling the changes in composition and texture, appears to be a late crystallization jointing effect. The medium grained nonporphyritic inner zone might be the chilled top of the intrusion.

The age of the Devils Room granite is not known. Heyl (1937) and Lock (1969a) considered it to be Paleozoic in age based on lithological similarities with parts of the Devonian Gull Lake intrusive suite to the southeast. However, as the Devils Room granite lacks the variety of phases seen in this suite and as there is no evidence of either granite intruding the intervening Coney Arm Group, the Devils Room granite is here considered to be late Precambrian in age. It is probably similar to other posttectonic granites found in other parts of the Long Range Complex (Bostock *et al.*, 1976; Pringle *et al.*, 1971).

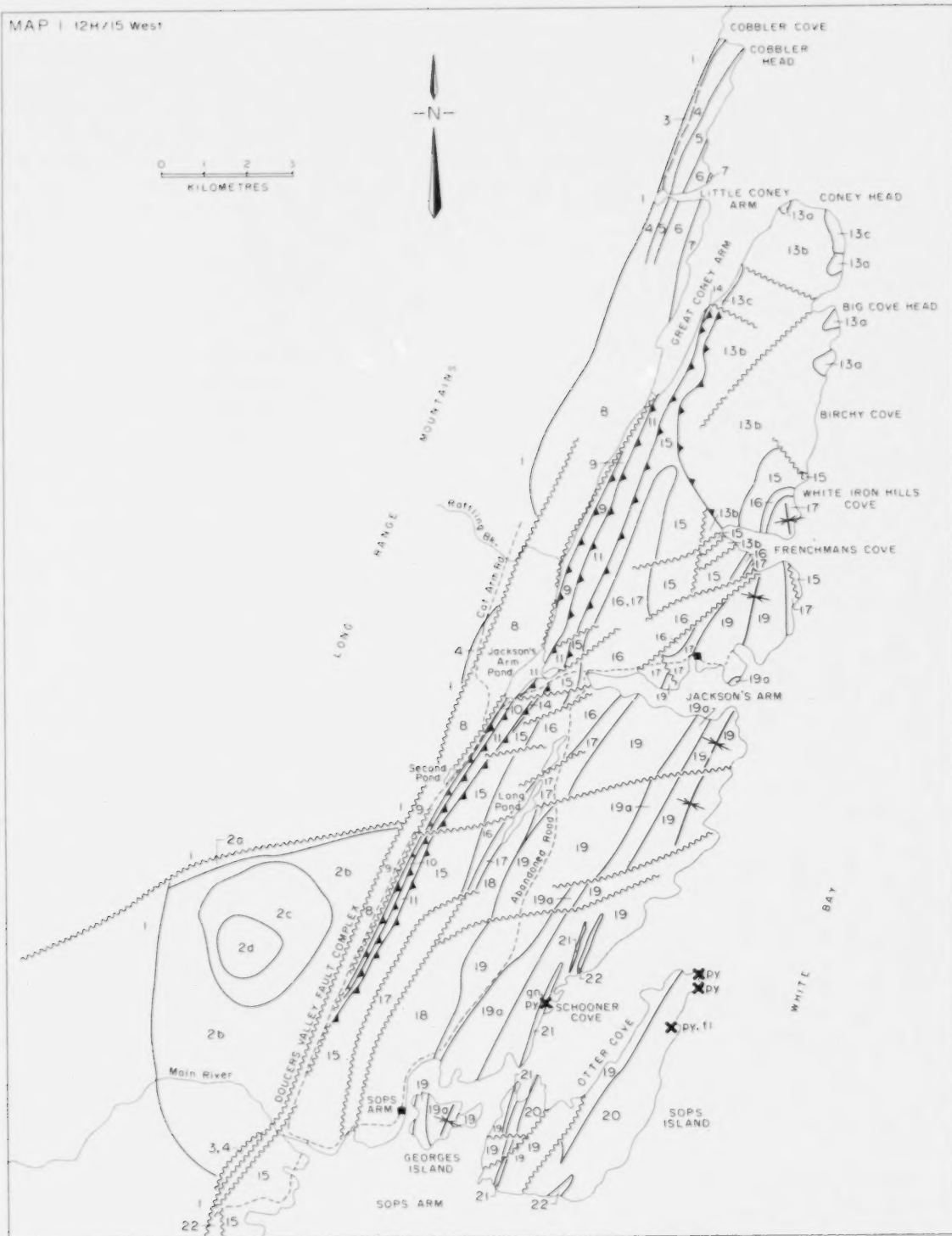
CONEY ARM GROUP - THE AUTOCHTHON (UNITS 3-8)

Clastic-carbonate rocks of the autochthonous Coney Arm Group (Lock 1969a, 1972a) lie to the east of, and locally unconformably overlie, the Long Range Complex (Maps 1 and 2). The Group is intensely deformed, however to the north of Great Coney Arm (Map 1), the rocks are vertically dipping, less deformed and a stratigraphy can be established. Rock units can be traced southwards with some success but more detailed mapping is required in inland areas to firmly establish the stratigraphy and structure.

BEAVER BROOK FORMATION (UNIT 3)

The Beaver Brook Formation (Heyl, 1937; Neale and Nash, 1963) is here redefined to include only the basal

MAP 1 12H/15 West



MAP 2 12H/10 West and part of 12H/11

Scale: 0 1 2 3 4 KILOMETRES

North Arrow: N

Geological Features and Labels:

- Long Range Mountains**
- Country Cove**
- SPEAR COVE**
- White Bottom Pond**
- Moore L.**
- Unknown Brook**
- Browning Mine**
- Corner Brook Pond**
- Freeman Prospect**
- Side Pond Prospect**
- Turners Ridge Prospect**
- Clam Pond**
- Woods Road**
- Clam Pond**
- Brook**
- Gull Lake**
- Gull Pond**
- White Bay**
- Hamden**
- Capot Fault**
- Birchy Ridge Fault**
- Sooty Arm Road**
- End of road 1381**
- Water Pond**
- Clam Pond**
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LEGEND

CARBONIFEROUS AND OLDER(?)

- 27 Deer Lake Group: Poorly indurated, red conglomerate and sandstone.
- 26 Anguille Group: Well indurated, gray sandstone, shale, minor red beds.

DEVONIAN AND OLDER

GULL LAKE INTRUSIVE SUITE (Units 23-25)

- 25 25a, Moose Lake granite: Megacrystic, biotite granite; 25b, Gull Pond granite: Fine to medium grained, biotite granite; 26c, medium grained biotite granite.
- 24 Gabbro, diabase and mafic intrusion breccias.
- 23 Biotite granodiorite to tonalite.

SILURIAN

- 22 Pink felsite dikes and sills.
- 21 Quartz monzonite sills

SOPS ARM GROUP (Units 14-20)

Natlins Cove Formation (Units 19 and 20)

- 20 Volcanic rocks: Predominantly ash flow tuffs and rhyolite flows, minor mafic volcanic flows.
- 19 Sedimentary rocks: Limy siltstone and sandstone, minor limestone; 19a, Lighthouse Member, white sandstone.
- 18 Simms Ridge Formation: Slate and argillite, minor limestone.
- 17 Frenchmans Cove Formation: Bedded polymictic conglomerate and coarse sandstone.
- 16 Jacksons Arm Formation: Massive, polymictic conglomerate.
- 15 Lower Volcanic formation: Welded and unwelded ash flow tuffs, flow banded rhyolite, minor mafic flows; 15a, dolostone and thin bedded limestone.
- 14 Quartz-carbonate schist. Age and origin uncertain.

MIDDLE ORDOVICIAN TO CAMBRIAN(?)

SOUTHERN WHITE BAY ALLOCHTHON

- 13 Coney Head Complex: 13a, Gabbro; 13b, tonalite; 13c, graphitic microgranite; 13d, muscovite leucogranite; 13e, zone of mafic to intermediate dikes.
- 12 Gabbro, trondhjemite, talc-carbonate schist.
- 11 Murrays Cove Schist: Polydeformed greenschist, mafic tuff, metagabbro and chert.
- 10 Maiden Point Formation equivalents: Fine to medium grained, dark green graywacke and slate.
- 9 Taylors Pond Formation and Second Pond Melange: Graphitic slate, minor calc- argillite, with exotic blocks and slivers.

MIDDLE ORDOVICIAN TO CAMBRIAN

CONEY ARM GROUP (AUTOCHTHONOUS)

- 8 Undivided recrystallized, limestone, dolostone and marble.
- 7 Limestone formation: Dark gray, recrystallized limestone, minor cherty dolostone.
- 6 Dolostone formation: White dolostone, minor dark gray limestone.
- 5 Hawke Bay Formation equivalents: Quartzite, sandstone, sandy dolostone, oolitic limestone.
- 4 Forteau Formation equivalents: Graphitic slate, phyllite, calcareous schist and marble.
- 3 Beaver Brook Formation: Arkose, sandstone.

PRECAMBRIAN OR YOUNGER

- 2 Devils Room Granite: Undeformed granite, age unknown; 2a, fine grained, pink felsite; 2b, megacrystic K-feldspar biotite granite; 2c, K-feldspar porphyritic biotite granite; 2d, medium grained, biotite $\pm$ muscovite granite.

PRECAMBRIAN

LONG RANGE COMPLEX

- 1 Granite gneiss, amphibolite, anorthosite, gabbro and granite.

clastic rocks that directly overlie the Long Range Complex. Overlying marbles, phyllites and slates previously included in the formation are separated as another formation, thus making the stratigraphic divisions in this area consistent with those established elsewhere for the autochthonous sequence of western Newfoundland (see Schuchert and Dunbar, 1934; Knight and Saltman, 1980).

The type section of the redefined formation is at Cobbler Cove (Map 1) where an estimated 22 m of gray sandstone, pebble conglomerate, arkose and hematitic sandstone is exposed. The base and top of the formation are exposed but a small part of the sequence is hidden. The formation is lithologically identical to the Eocambrian Bradore Formation (Schuchert and Dunbar, 1934) exposed around the northern margin of the Long Range Inlier.

FORTEAU FORMATION EQUIVALENTS (UNIT 4)

The name Forteau Formation equivalents is provisionally assigned to the interbedded marbles, graphitic phyllites and schists that conformably overlie the Beaver Brook Formation. The formation marks the beginning of carbonate deposition on the western platform, which in the Canada Bay area to the north has been dated as extending from Lower Cambrian to Lower Middle Ordovician. The type section is along the shore of Cobbler Cove (Map 1).

The basal part of the formation is characterized by a white, bedded, marble that can be correlated with the Lower Cambrian Devils Cove Formation (Betz, 1939) in Canada Bay to the north. This is overlain by a mixed sequence of dark gray, fine grained, muscovite and graphite bearing pelitic schists, calcareous schists, with thin, prominent marble beds. The formation is characterized by quartz veins and pods and complicated recumbent folds.

Muscovite, sericite and locally biotite in the south define a strong S_1 schistosity that is folded about numerous, westerly verging recumbent folds.

HAWKE BAY FORMATION EQUIVALENTS (UNIT 5)

An interbedded sequence of oolitic limestone, sandy dolostone, orthoquartzite, limy slate and calcareous sandstone conformably overlies the Forteau Formation equivalents. The sequence occupies a similar stratigraphic position and is lithologically identical to the oolitic limestone-mudstone-quartzite formation of Knight and Saltman (1980) in Canada Bay, which they considered to be laterally equivalent to the Hawke Bay Formation on the western side of the Long Range Inlier. For these reasons, the formation is provisionally named Hawke Bay Formation equivalents.

The formation is well exposed along the coast south of Cobbler Head (Map 1) but is locally disrupted by a thrust and minor normal faults. The base of the formation is drawn at the first appearance of interbedded limestones and dolostones overlying black, graphitic pelites of the Forteau Formation equivalents.

The basal part of the formation at Cobbler Head consists of five reddish weathering, gray dolomite beds from 0.5 to 1 m thick interbedded with dark gray oolitic and oncolitic limestones. A thrust fault that separates oolitic limestones from slates and phyllites of the Forteau Formation equivalents is exposed in a small cove 400 m south of Cobbler Head. The contact is marked by 2 m of breccia. The beds on the upper plate dip steeply to the east, whereas those in the sole are subhorizontal. The upper plate contains distinctive orthoquartzites. The orthoquartzites are fine grained, laminated, crossbedded and locally highly disrupted by slumps. They

occur in laterally persistent beds up to 4 m thick.

DOLOSTONE FORMATION (UNIT 6)

A formation of thick, well bedded, white weathering dolostone, dolomitic limestone and minor gray limestone overlies the Hawke Bay Formation equivalent. It is excellently exposed on the sea cliffs at the entrance to Little Coney Arm (Map 1) where it faces eastwards in subvertical to overturned beds. The dolostones occur in beds up to 1 m thick and display numerous shallow water sedimentary features such as mud cracks, ripple marks, and thin dessication breccias along the tops of beds. These were incorrectly interpreted by Lock (1969a) as channel breccias.

LIMESTONE FORMATION (UNIT 7)

Near the entrance to Little Coney Arm (Map 1) the dolostone formation passes transitionally upwards into a sequence of dark gray limestones with abundant chert lenses and nodules and minor white dolostone interbeds. These pass up into a sequence of dark gray, rubbly weathering, limestones which form the top of the exposed sequence in Great Coney Arm.

The limestones at the base of the formation are extensively burrowed and contain algal mats and stromatolites. Stouge (personal communication, 1980) recovered conodonts from the middle part of this formation that indicate a Lower Ordovician (Canadian) age. Poorly preserved coiled gastropods were discovered 1.5 km south of Little Coney Arm.

Southwards from Little Coney Arm the beds deviate from the vertical and are folded, intensely tectonized and recrystallized. Bedding is obscure and in most places the formations described above could not be distinguished with certainty. Such rocks as shown on the map are undivided recrystallized limestone, dolostone and marble (Unit 8).

Breccias

A number of breccias in bands and pods up to 6 m thick are developed in the limestones and minor dolostones of Unit 7 in Rattling Brook (Map 1) and on the northwest side of Taylors Pond (Map 2). Those in Rattling Brook (Gorge tributary of Lock, 1969a) were interpreted by Lock (1969a, 1973) as synsedimentary breccias deposited in channels at the carbonate bank edge. However, the sedimentological evidence suggests that the immediately underlying formation (Unit 6) was deposited in an intertidal to supratidal environment. The carbonates were probably exposed periodically, leading to formation of dessication breccias along the tops of beds such as seen in the Little Coney Arm section. Unit 7 limestones were deposited in deeper water, probably subtidal conditions. There is no evidence to support Lock's thesis that these units formed as slope deposits traversed by channels in which breccias were deposited.

In Rattling Brook, the breccias occur in subvertical bands from 10 m to 0.5 m wide within a white dolostone and limestone sequence. They have sharp contacts with unbrecciated rock. The breccias are unsorted and ungraded with clasts up to 1 m across but most range from 30 to 50 cm across. The breccias have a pink to white calcite cement, but the thickest breccia horizon in Rattling Brook contains in addition a green clastic cement that is locally hematized. The clasts have well developed internal foliations and the haphazard orientation of the foliated clasts indicates the host was deformed prior to breccia formation.

These breccias clearly formed after the regional penetrative deformation and metamorphism and are probably tectonic in origin.

Similar breccias that postdate the regional deformation also occur at the northwest end of Taylor's Pond. There the breccias have a red, hematitic

cement that is locally cleaved indicating later minor deformation in this area.

The breccias in both localities occur near the easternmost exposures of the Coney Arm Group, its boundary being a major fault line named the Doucers Valley Fault Complex (Lock, 1972a). The breccias are here considered to be the result of brittle deformation related to late tectonic movements (post-Acadian) on this fault.

SOUTHERN WHITE BAY ALLOCHTHON (UNITS 9-13)

Rocks that lie between the Ordovician and older Coney Arm Group and the Silurian Sop's Arm Group and separated from them by faults are considered to be allochthonous and are assigned to the newly proposed Southern White Bay Allochthon. The allochthonous nature of some of these rocks was first proposed by Williams (1977) but this work has identified additional slices and shown that the allochthon is much more extensive and lithologically diverse than first described.

Pre-Carboniferous rocks that outcrop along the southwest shore (Map 2) of White Bay (Hyde, 1979) are here also considered to be part of the allochthonous sequence, which were further imbricated during Hercynian orogenesis.

TAYLOR'S POND FORMATION AND SECOND POND MELANGE (UNIT 9)

Bordering the Coney Arm Group on its eastern side and separated from it by a high angle fault is a narrow belt of black, graphitic and pyritic slate and phyllite named the Taylor's Pond Formation (Lock, 1969a; Williams, 1977). The formation is characterized by laminated limy argillites up to 0.5 m thick and by numerous quartz veins and pods.

Apparently within the formation are areas of melange, the Second Pond Melange (Williams, 1977), and slivers of fine grained green graywacke.

The Taylor's Pond Formation is well exposed at the junction of Rattling Brook and Jackson's Arm Pond River and along the Jackson's Arm road (Map 1). Melange is best exposed in road cuts opposite Second Pond and an isolated serpentinite block occurs near the southeast end of Taylor's Pond (Map 2).

The age and stratigraphic position of the Taylor's Pond Formation is not known, but is here considered to be part of the allochthon; however, other interpretations are possible, *viz*

1. It stratigraphically overlies limestones of the Coney Arm Group and is correlative with Middle Ordovician Goose Tickle Formation which occurs at the top of the autochthonous sequence in western Newfoundland (*cf.* Williams, 1977).

2. It is a paraautochthonous thrust slice of the Lower Cambrian Forteau Formation equivalents (Smyth, 1981). The melange and graywacke slivers were tectonically incorporated during thrusting.

3. It is allochthonous and possibly equivalent to the Tremadocian Northwest Arm Formation (Tuke, 1968) of the Hare Bay Allochthon to the north.

Interpretation 1 of Williams (1977) is rejected as the formation lacks flyschoid sandstones typical of the Goose Tickle Formation. In addition there is no evidence that the upper part of the autochthonous sequence, *viz* the Table Head Formation and the Goose Tickle Formation, is preserved anywhere in the area.

The difference between interpretation 2 and 3 is age and distance travelled of the two formations. If the formation is equivalent to the Forteau

Formation, then a simple reverse fault would juxtapose it against the limestones of Unit 7. On the other hand, if it correlated with the Northwest Arm Formation, then it presumably was transported from the paleo-continental slope that lay an unknown distance to the east.

The formation contains a number of impure limestone beds which might yield conodonts.

MAIDEN POINT FORMATION EQUIVALENTS (UNIT 10)

Medium to fine grained, green schistose graywacke and slate form a separate slice in the allochthon as well as tectonic slivers in shales of the Taylor's Pond Formation. The thrust sheet overlies the Taylor's Pond Formation and is structurally overlain by the Murray's Cove Schist. The rocks are named the Maiden Point Formation equivalents as they are lithologically identical to the lower Cambrian(?) Maiden Point Formation in the Hare Bay allochthon (Williams, 1975) to the north.

It outcrops from Jackson's Arm Pond 10 km southwards where it is removed along the Doucers Valley Fault Complex but reappears at Taylor's Pond to the south. The formation also occurs in post-Carboniferous thrust sheets on the southwest shore of White Bay (Map 2).

The graywackes are characterized by blue quartz grains and interbedded minor quartz pebble conglomerates typical of the type formation at Hare Bay.

MURRAYS COVE SCHIST (UNIT 11)

The Murrays Cove Schist (Lock, 1969a; Williams, 1977) forms the next highest thrust slice of the allochthon. It consists of polydeformed and metamorphosed mafic tuffs and breccias, with rare, thin, calcareous tuffs, red chert and metagabbro pods. Williams (1977) grouped the schists and nearby igneous rocks into the Coney Head

Complex and stated that there was a structural and metamorphic gradation between them. However, this work has shown that the two rock types form separate structural units separated from each other by a thrust wedge of Silurian rocks (Map 1) and are consequently described separately.

The schists are intruded by rare, pre-tectonic, gray, feldspar porphyritic, felsic dikes from 0.3 m to 10 cm wide. The dikes occur throughout the formation but are more abundant towards the top at Murrays Cove.

The schists have been traced southwards from Great Coney Arm to near Sops Arm (Map 1) where they are pinched out along the Doucers Valley Fault Complex. South of Jackson's Arm they are difficult to distinguish in the field from adjacent mafic flows of the Sops Arm Group. However, the latter tend to be less schistose, and have interbedded polymictic conglomerate beds and red cherts.

The Murrays Cove Schist is identical to parts of the dynamothermal aureole that is underpinned to slices of ophiolite in the Hare Bay and Humber Arm Allochthons (Williams and Smyth, 1973).

UNIT 12

Unit 12 consists of slivers of deformed gabbro, trondhjemite and talc-carbonate schist and outcrops along the southwest shore of White Bay. It is interpreted as remnants of a disrupted ophiolite and as such is considered part of the Southern White Bay Allochthon.

Unit 12 is separated by steep, easterly dipping, reverse faults from the Anguille Group to the west and from greenschists of Unit 11 to the east. Ophiolitic rocks in the other western Newfoundland allochthons always form the highest structural slices and the disruption of this stacking order in White Bay is probably a result of the post-Lower Carboniferous reverse faults.

CONEY HEAD COMPLEX (UNIT 13)

The term Coney Head Complex (Williams, 1977) here refers to an intrusive sequence of gabbro and quartz gabbro (5%), trondhjemite and tonalite (90%), biotite microgranite (5%) and muscovite leucogranite (>1%) that occurs south of Coney Head (Map 1). Also included is a zone of intrusion breccia of the above rock types that is cut by a swarm of mafic to silicic dikes.

The exact age of the complex is not known. It is unconformably overlain (Williams, 1977) by rhyolite breccias of the Silurian Sops Arm Group at its southeast margin. Its western margin is a thrust contact with the Sops Arm Group. It is believed to be part of a Taconic Allochthon as first suggested by Williams (1977) as possible correlatives in the Humber Arm Allochthon and elsewhere likely formed in an oceanic domain east of the Baie Verte Lineament (Williams, 1977).

Gabbro grades into quartz gabbro (13a); both are medium grained and massive to locally foliated. Locally, they contain oval shaped, pegmatitic patches up to 30 cm across that consist of hornblende, feldspar and minor quartz. Layered schlieren, generally with northwest trends, were observed in coastal exposures south of Big Cove Head and west of Coney Head (Map 1). The schlieren occur as troughs and bands that are truncated by massive gabbro.

The gabbro-quartz gabbro is intruded by a medium to coarse grained tonalite (13b), which comprises over 90% of the complex. Spectacular intrusion breccias occur at the contacts with the gabbros and locally throughout the tonalite. At the contacts, the gabbro xenoliths have rounded and cusped margins but within the tonalite some xenoliths are intensely flattened and define a northwest trending fabric. There is a gradation between tonalite and trondhjemite throughout the complex.

At Coney Head the tonalite-gabbro phases are intruded by a purple to red, biotite, graphic microgranite (13c). This unit is characterized by numerous small (5 to 10 cm) rounded and oval shaped inclusions of dark green diabase. Most are medium to fine grained and some have scattered feldspar phenocrysts. Composite silicic-mafic dikes occur in this unit.

In the Birchy Cove area (Map 1) the tonalite is cut by sheets of pink, medium to coarse grained, muscovite, alkali-feldspar granite (13d). They are extensively veined by quartz and contain pyrite disseminations.

On the east shore of Great Coney Arm, intrusion breccias are cut by numerous silicic and minor mafic porphyry dikes (13e). The silicic dikes resemble those in the Murray's Cove Schists nearby.

Deformation in the complex is variable. The early northwest trending foliation is rare. A penetrative, northeast trending Acadian cleavage is zonally developed especially at Coney Head, near the unconformity at White Iron Hills Cove and along the western margin of the complex within 1 km of the thrust contact with the Silurian Sops Arm Group.

SOPS ARM GROUP (UNITS 14-20)

The geology of the Silurian Sops Arm Group was previously well known from the work of Heyl (1937), Lock (1969a) and Noranda Exploration Ltd. (summarized in Dimmell, 1979). This work has refined the distribution of the various formations, especially north of Jackson's Arm. The only changes proposed here to the nomenclature of Lock (1969a) are as follows:

(1) The three basal volcanic formations - White Iron Hills, Main River and Stoney Hill - are grouped into one formation. As suggested by Lock (1972a) these are lateral facies

equivalents and extend the entire length of the map area. The Main River and Stoney Hill formations are well exposed and distinctive in their type area at Sops Arm and could be retained as members of the Lower Volcanic formation (informal name).

(2) Volcanic rocks near the top of the Group occur in three belts separated by sedimentary rocks. Each belt contains similar lithologies to the others and Lock's (1969b) five-fold subdivision of the upper volcanics, made from detailed examination of coastal exposures, were difficult to establish inland. Consequently, the terms are not used in this report but are referred to where appropriate.

QUARTZ-CARBONATE SCHIST (UNIT 14)

Unit 14 consists of a brown weathering quartz-carbonate-sericite schist. It forms a narrow band between greenschists of the Murrays Cove schist to the west and volcanic rocks of Unit 15 to the east. It is exposed on the Jacksons Arm road and at Great Coney Arm.

The age and origin of Unit 14 is uncertain. It contains an unidentified bright green mineral which could be either sericite or fuchsite. If it is the latter, then this rock could be an altered ultramafic and be part of the allochthonous sequence, but the field evidence suggests it is an altered felsic volcanic rock and hence is included in the Sops Arm Group.

LOWER VOLCANIC FORMATION (UNIT 15)

The Lower Volcanic formation consists predominantly of felsic ash flow tuffs, rhyolite flows with lesser mafic flows and minor interflow conglomerate, sandstone and dolostone. The formation extends from White Iron Hills Cove (Map 1) southwards parallel to the Doucers Valley Fault Complex. The basal parts of the formation are strongly sheared close to the fault. The

formation is bifurcated by the Gull Lake intrusive suite south of Sops Arm (Map 2).

A felsic pyroclastic breccia unconformably overlies the Coney Head Complex at the White Iron Hills Cove. At the northwest side of Sops Arm (Map 1), the base of Unit 15 consists of sheared and altered rhyolite, now a quartz sericite schist, overlain by vesicular mafic flows and minor polymictic conglomerate. These are overlain by a sequence of flow banded rhyolites with minor welded crystal tuffs (Main River Formation of Lock, 1969a). This is overlain by a sequence of seven ash flow tuffs that are predominantly strongly welded (Stoney Hill Formation of Lock, 1969a). West of Long Pond (Map 1), the ash flows are overlain by a coarse, monomictic volcanic breccia that contains densely packed, subrounded, purple, feldspar porphyry clasts from 20 to 50 cm across. Some of the clasts have altered rims.

From the north end of Taylors Pond southwards to the south end of the map area, a thin dolostone-calc-argillite horizon (Subunit 15a) occurs within the Lower Volcanic formation. This horizon hosts subeconomic lead mineralization and was mapped and explored in detail by Noranda Exploration (Dimmell, 1979).

JACKSONS ARM FORMATION (UNIT 16)

The Jacksons Arm Formation (Heyl, 1937; Lock, 1969a) is a massive, unsorted, cobble to boulder, polymictic conglomerate unit. The conglomerates are similar to thin, interflow conglomerate horizons in the Lower Volcanic formation but in the north of the area they define a 600m thick unit that overlies the volcanics. South of Long Pond only minor conglomerate beds were observed and there is no mappable conglomerate formation. Its stratigraphic position is marked by a strong lineament suggesting that facies changes alone may not be responsible for its absence.

The formation is best exposed in Frenchmans Cove (Map 1) where it contains a number of intercalated mafic volcanic flows up to 4 m thick and rare sandstone beds.

The clasts are composed predominantly of felsic volcanic lithologies with rare argillite, sandstone, shale, chert, granite, gneiss and gabbro clasts.

FRENCHMANS COVE FORMATION (UNIT 17)

The Frenchmans Cove Formation (Lock, 1969a) consists of interbedded, pebble to boulder polymictic conglomerate and medium to coarse grained sandstone. It gradationally overlies and occurs in the same general area as the Jacksons Arm Formation (Map 1). The transition is marked by a decrease in clast size, increased sorting and the occurrence of well defined bedding in the conglomerates. Inland, it is often difficult to decide which formation an isolated conglomerate outcrop should be assigned to, and both formations should probably be viewed as members of one formation.

SIMMS RIDGE FORMATION (UNIT 18)

The Simms Ridge Formation (Heyl, 1937; Lock, 1969a) consists of a sequence of brown weathering, pale green-gray slate, siltstone, minor fine grained sandstone and limestone. It intervenes between the Lower Volcanic formation and the sandstones of the Natlins Cove Formation in the south of the area. To the north it pinches out between the Frenchmans Cove Formation and the Natlins Cove Formation near Long Pond and apparently was not deposited north of there. Northward shallowing of the basin and preponderance of coarse clastic rocks may account for its absence in that area (Lock, 1969a, 1972a).

Although the formation is named after Simms Ridge, a hill north of Pinkstons Mill Road (Map 2), the type

section is on the south shore of Sops Arm. There the basal contact with the Lower Volcanic formation is unexposed but to the south at Unknown Brook (Map 2), the contact is a fault.

The characteristic feature of the formation is the occurrence of brown weathering, posttectonic siderite spots (Lock, 1969a). Their origin and significance has yet to be investigated. Fossiliferous limestones and marbles in beds up to 3 m thick are an integral feature of the formation. They contain gastropods, crinoids, corals and rare brachiopods that indicate a Middle Silurian age (Lock, 1972a).

NATLINS COVE FORMATION (UNITS 19 AND 20)

The Natlins Cove Formation (Heyl, 1937; Lock 1969a) consists of a mixed sequence of shallow marine sandstones and subaerial felsic and minor mafic volcanic rocks. The volcanic rocks occur in two belts on the south shore of Sops Arm and on Sops Island and this work has delineated another belt of volcanic rocks between the other two in the area south of the end of the Pinkstons Mill Road (Map 2). All three volcanic belts are composed of varying amounts of subaerial volcanics including flow banded rhyolite flows, ash flow tuffs, air fall tuffs, lahars, minor mafic flows and minor felsic intrusive rocks.

Lock (1969a) mapped the lower and upper belts and subdivided them into members. However, as the same lithology occurs in each of the three belts, it is difficult to decide in the field to which member an outcrop should be assigned. A further mapping problem exists in the region southeast of Davis Pond (Map 2) where the volcanic rocks of the Natlins Cove Formation lie adjacent to the Lower Volcanic formation. Both formations contain similar lithologies and it is possible that they could be the same formation repeated by folding and/or faulting. However, available top determinations suggest the volcanic sedimentary rocks of the Natlins Cove

Formation are interbedded and form an east-facing conformable sequence. A detailed paleontological study and structural analysis of the coastal exposures is necessary to confirm this. The abundant limestone beds throughout the formation contain poorly preserved macrofossils, but samples from Spear Cove (Map 2) were found to contain identifiable Silurian conodonts (Stouge, personal communication, 1980) indicating a useful field of future study.

Sedimentary rocks (Unit 19)

The dominant rock of this unit is a fine grained, gray, sandstone with lesser limy siltstone, shale and thin limestone beds.

In the north of the area the sandstones pass transitionally upwards from the coarser clastics of the Frenchman's Cove Formation. The transition is marked by the disappearance of coarse clastics and the appearance of limestones. South of Jackson's Arm sandstones and calcarenites of the formation gradationally overlie spotted slates of the Simms Ridge Formation.

Within the gray sandstones in the north of the area is a band of well bedded, white, medium grained sandstones and orthoquartzite named the Lighthouse Beds by Lock (1969a). The beds are well exposed at the lighthouse at Jackson's Arm where they display large scale trough crossbedding that indicate paleocurrent flow from the north. To the south, the beds are darker coloured and contain siltstone interbeds. They are not seen south of Georges Island (Map 1) where they apparently occupy the core of a north plunging syncline.

Conglomerate and coarse volcaniclastic rocks occur in spatial association with the volcanics. They are best exposed on the east shore of Sops Island.

Volcanic rocks (Unit 20)

Rhyolite: Pink to dark gray, flow banded rhyolites occur in each of the three volcanic belts. They contain both quartz and feldspar phenocrysts and bands of opaque minerals. Rhyolite is the dominant lithology in the easternmost belt. A part of this belt, exposed at Otter Cove on Sops Island, is underlain by what looks like a flow banded rhyolite in the field but was identified by Lock (1972b) as a rheo-ignimbrite.

Ash Flow Tuffs: Welded and unwelded, lithic and crystal lithic ash flow tuffs are common in all three belts. They overlie and are locally overlain by flow banded rhyolite. Individual flow units, separated by air fall tuffs and/or bedded epiclastic rocks can be distinguished on the highlands south of Sops Arm. Large parts of the upper belt on Sops Island are composed of pyroclastic breccias presumed to have been deposited by ash flows proximal to a vent.

Air Fall Tuffs: These are soft, poorly bedded and unsorted with lithic clasts from 1-5 cm across. They are best seen in Sops Arm 0.5 km west of White Point.

Mafic Volcanics: Mafic volcanic rocks occur in the central and eastern belts and consist of green, chloritized, vesicular and amygdaloidal flows with minor interflow mafic tuff and rare feeder(?) dikes. They are well exposed at the east end of Pinkstons Mill Road and on the shore of Spear Cove (Map 2).

Laharic Breccias: Lahars were recognized in the central and eastern volcanic belts on Pinkstons Mill Road and Sops Island. They consist of coarse rhyolite and feldspar porphyry clasts from 2 to 20 cm across dispersed in a tuffaceous matrix.

INTRUSIVE ROCKSGRANITOID SILLS AND DIKES
(UNITS 21 AND 22)

A number of pre-tectonic granitoid sills and dikes cut the Simms Ridge and Natlins Cove Formations. Most are fine grained, pink, rhyolites that are commonly cut by postcleavage, quartz-filled fractures and veins. A feldspar porphyritic sill which cuts the Natlins Cove sediments at Schooner Cove and on adjacent Sops Island was reported by Lock (1969a) to be a quartz monzonite. The adjacent fine grained sandstones are hornfelsed at the contacts.

GULL LAKE INTRUSIVE SUITE (UNITS 23-25)

The name Gull Lake intrusive suite is here proposed for the large suite of granodiorite, gabbro and diabase, megacrystic biotite granite and fine grained biotite granite that intrudes the Sops Arm Group south of Sops Arm (Map 2). It was previously referred to as the Gull Lake granite (Lock, 1969a) and the Gales Brook stock (Hyde, 1979) but this is the first recognition and definition of the various phases.

Granodiorite (Unit 23)

The earliest phase of the suite is a medium to coarse grained, biotite granodiorite to tonalite. The rock is light gray, massive to foliated and is interpreted as a pre- or syn-Acadian intrusion. Intrusive contacts with the Sops Arm Group are exposed on Gull Pond Brook and south of Davis Pond. Xenoliths of amphibolite and quartz-biotite-feldspar schists (metavolcanic rocks) are common near the contacts. The granodiorite is clearly intruded by the other phases of the suite.

Gabbro and diabase (Unit 24)

A roughly northeast trending Y-shaped belt of diabase and gabbro occupies the southern part of the suite.

It consists mainly of massive, weakly foliated, subophitic diabase and microgabbro with minor mafic dikes and patches of pegmatitic gabbro. The gabbro and diabase form intrusion breccias and small intrusions within the earlier granodiorite; the contact with it is gradational over 500 m. Within the unit itself there are both sharp and diffuse intrusive contacts between diabase and gabbro.

A swarm of late to post-tectonic diabase dikes cut the Maiden Point Formation equivalents south of Taylors Pond (Map 2). They were not observed to cut the adjacent Sops Arm Group and their age and relation to this unit is not known.

Moose Lake Granite (Subunit 25a)

The name Moose Lake granite is informally applied to the coarse grained to megacrystic biotite granite that forms a linear shaped pluton along the western and southeastern margin of the suite. It intrudes the Sops Arm Group and the earlier phases of the suite and west of Moose Lake is juxtaposed against the Coney Arm Group by the Doucers Valley Fault Complex.

The granite is pink to red, with microcline phenocrysts up to 8 cm long. It is generally massive except close to faults such as the Doucers Valley and Birchy Ridge faults where it is sheared with extensive chlorite alteration.

Dikes of the granite clearly crosscut cleaved Sops Arm Group sediments southeast of Moose Lake and in this area a biotite hornfels up to 1 km wide is developed in the country rocks. Amphibolites (metavolcanics) near the contact were incorrectly identified as Grenville Gneiss by Lock (1969a).

Large xenoliths of quartzofeldspathic and calc-silicate gneiss occur within the Moose Lake granite near Clam Pond at the southern boundary of the map area. These highly deformed and

metamorphosed rocks represent either fragments of the Long Range Complex or metamorphosed Coney Arm Group brought up in the granite.

Gull Pond Granite (Subunit 25b)

The name Gull Pond granite is here informally applied to an oval shaped pluton of fine to medium grained, biotite + muscovite, pink, granite that lies west of Gull Pond. It intrudes the Sops Arm Group and the older granodiorite and diabase/gabbro and is considered to be a high level, separate pluton related to the Moose Lake granite. It is locally porphyritic with scattered feldspar phenocrysts up to 3 cm in size. Fine grained dikes of this granite occur outwards from it and clearly cut the country rocks posttectonically.

Another small, unnamed, medium grained, biotite granite pluton (Subunit 25c) occurs west of Davis Pond.

ANGUILLE GROUP (UNIT 26)

Lower Carboniferous and older(?) clastic rocks of the Anguille Group (Hyde, 1979) border the older rocks to the east along the southwest side of White Bay. The contact is a major, possibly dextral strike slip fault, named the Birchy Ridge Fault (Belt, 1969).

In the map area, the Anguille Group consists predominantly of coarse to fine grained dark gray micaceous sandstone, pebbly sandstone and black slate. These rocks are described in detail by Hyde (1979).

DEER LAKE GROUP (UNIT 27)

Clastic rocks assigned to the Visean Deer Lake Group occur to the southwest of the Gull Lake intrusive suite. Gently dipping red conglomerates and sandstones unconformably overlie all of the older geological elements. Westward directed thrusting of the Sops

Arm Group and the Gull Lake intrusive suite over the Deer Lake Group has eradicated the unconformity in the Turners Ridge - Alder Brook region (Dimmell, 1979). The Deer Lake Group was also studied by Hyde (1979).

STRUCTURE

The occurrence of dated Ordovician, Silurian and Carboniferous rocks in the area affords a unique opportunity to unravel the effects of the various Paleozoic orogenies that occurred on the western margin of the Newfoundland Appalachians.

The mid-Ordovician Taconic Orogeny resulted in emplacement of the Southern White Bay Allochthon over the autochthonous Coney Arm Group. It produced west facing, recumbent folds with a penetrative muscovite-biotite schistosity in clastics of the Coney Arm Group and a strong, penetrative, greenschist schistosity in the Allochthon. Its upper age is bracketed by the unconformity of the Silurian Sops Arm Group on the Coney Head Complex.

The Acadian Orogeny (Devonian) affected the Sops Arm and Coney Arm Groups and the Allochthon. Intrusion of the syntectonic to posttectonic Gull Lake intrusive suite occurred at this time. Acadian thrusting resulted in imbrication of the Sops Arm Group with the Allochthon in the Doucers Valley Fault zone in the north of the area. Deformation and metamorphism in the Sops Arm Group increase towards this fault zone. Open, upright folds in the east become tighter and inclined towards the west.

Hercynian (Carboniferous) deformation produced upright, tight folds in the Anguille Group (Hyde, 1979) and locally juxtaposed the Anguille Group and the allochthonous rocks along steeply dipping faults north of Hampden. The Visean Deer Lake Group was not affected by this period of folding (Hyde, 1979) and may not have been

deposited at that time. However, in the Turners Ridge area, the Sops Arm Group is locally thrust over the Deer Lake Group (P. Dimmell, personal communication, 1980).

Three major rectilinear northeast trending faults traverse the area; the Doucers Valley Fault Complex (Lock, 1969a, 1972a), the Birchy Ridge Fault (Belt, 1969) and the Cabot Fault (Wilson, 1962). All are interpreted to have dominantly strike slip movements in the Lower Carboniferous (Hyde, 1979) but their early history has not been documented. It is clear from map relations and down-dip rodding lineations in conglomerates of the Sops Arm Group that early movement on the Doucers Valley Fault was a westerly directed thrust. Minor dextral strikeslip faults splay northeastwards off the fault and may relate to Acadian(?) thrusting or to Hercynian strike slip movements. The Visean Deer lake Group apparently unconformably overlies the Doucers Valley Fault system providing an upper limit for the age of displacement.

MINERALIZATION

CONEY ARM GROUP

Apart from small pyrite occurrences, especially in the basal clastics, no metallic mineralization of any significance was noted in the Coney Arm Group. The marble deposits have been previously described by Bain (1937), Heyl (1937), Lee (1956) and Bedford (1957). The marbles lie adjacent to the Doucers Valley Fault Complex and are highly contorted and fractured thus making them unsuitable for use as building stone. However, their potential as mineral fillers is increased by recent access provided by the Cat Arm road which crosses the group west of Jacksons Arm Pond and at Little Coney Arm (Map 1).

SOUTHERN WHITE BAY ALLOCHTHON

Soapstone

Ultramafic knockers in the Second Pond melange opposite the Cat Arm base camp on the Jackson's Arm road (Map 1) are thoroughly serpentized and locally altered to talc. The rock is extensively fractured but small quantities might be suitable for carving.

Chalcopyrite-molybdenite

A quartz-feldspar pegmatite up to 1.5 m across that cuts quartz gabbros of the Coney Head Complex 3.5 km south of Coney Head contains minor pyrite, chalcopyrite and molybdenite mineralization. The pegmatite could be related to the sheets of muscovite granite nearby to the south.

SOPS ARM GROUP

Galena-barite in dolomites

A dolomite horizon within the Lower Volcanic formation south of Taylor's Pond hosts two subeconomic, stratabound, galena deposits, the Turner's Ridge and Side Pond Prospects (Dimmell, 1979). Patchy mineralization occurs along the strike length of the dolomite from Taylor's Pond to Gales Brook, a distance of 20 km.

The mineralization occurs in association with barite, pyrite and rare sphalerite in fractures and veins. The fractures appear to postdate the regional Acadian deformation and for this reason the mineralization is interpreted as vein-type, possible related to intrusion of the nearby Moose Lake granite.

In the Turner's Ridge prospect, the mineralization occurs as a network of galena-barite veinlets up to 5 cm wide in brecciated dolomite. The Side Pond

Prospect consists of quartz-barite veins containing galena, pyrite and rare sphalerite cutting unbrecciated dolomite.

Another dolomite horizon within the Lower Volcanic formation 0.5 km northeast of Unknown Brook (Map 2) contains minor galena, malachite and azurite mineralization. A small area of medium grained granite occurs nearby which is here interpreted as an apophysis of the Moose Lake granite.

Pyrite + pyrophyllite in Lower Volcanics

Snelgrove (1935) reported a zone of pyrophyllite alteration in Unknown Brook hosted by felsic tuffs of the Lower Volcanic formation. Where the alteration is most intense, the tuffs consist of a compacted aggregate of spherulites up to 5 cm in diameter. The spherulites are flattened in the plane of the regional S_1 cleavage; they probably formed by devitrification during cooling of an ash flow.

Disseminated pyrite mineralization accompanied by pyrophyllite and sericite alteration occurs in the tuffs; however, no assays were reported by Snelgrove. The mineralization appears to accompany the regional shearing of the rocks. Posttectonic quartz veins contain scattered tourmaline crystals.

Rhyolites of the Lower Volcanic formation host minor malachite mineralization in a road quarry west of the Clam Pond road intersection. The mineralization occurs in brecciated rhyolite as fracture fillings and coatings.

Chalcopyrite, pyrite, galena in Simms Ridge limestone

Limestones within the Simms Ridge and Natlins Cove Formations south of Sops Arm contain small sulphide showings. Minor disseminated galena and pyrite in limestones near the base of the Simms Ridge Formation was discovered

in Corner Brook. A 5 cm thick white limestone bed exposed in an old woods road 0.6 km east of Corner Brook contains pyrite stringers parallel to bedding. The rock is characterized by a green, malachite stain on weathered surfaces.

Gold, silver, galena in quartz veins

Mineralized quartz veins cutting bedded tuffs of the Simms Ridge Formation (Browning Mine), limestones and shales of the Simms Ridge Formation (Freemans Prospect), welded ash flow tuffs of the Lower Volcanic Formation (West Corner Brook Prospects and Unknown Brook Prospects), a felsite dike in the Simms Ridge Formation (Simms Ridge Prospect) and another in the Natlins Cove Formation (Schooner Cove Prospect) were the targets of the earliest exploration in the area (1898-1935) (see Snelgrove, 1935). The quartz veins contain variable amounts of pyrite, and galena and rare sphalerite, chalcopyrite and specularite. Gold and silver values were reported by the earlier workers (Snelgrove, 1935; Heyl, 1937) although no visible gold was seen by the authors.

The West Corner Brook, Browning Mine, Unknown Brook and Freeman prospects are all located at or close to the faulted contact between the Lower Volcanic Formation and the Simms Ridge Formation. In all prospects, the quartz veins postdate the regional penetrative deformation but some are warped, kinked or brecciated. The mineralization is considered not to be volcanogenic in origin but related to a post-Acadian hydrothermal vein system probably associated with the last phase of the Gull Lake intrusive suite, the veins being controlled by faults and fractures.

GULL LAKE INTRUSIVE SUITE

Pyrite gossans in granodiorite

Small pyrite gossans were discovered in breccias of the

granodiorite phase of the Gull Lake intrusive suite south of Gull Pond (Map 2). The breccias have a green chloritic matrix which appears to be hornfelsed by the later phases. The breccias superficially resemble those found above porphyry deposits.

Fluorite and pyrite in the Moose Lake granite

A number of minor fluorite occurrences were discovered in the Moose Lake granite north and south of Moose Lake (Map 2). The fluorite occurs in small, discontinuous, narrow fractures and veins up to 10 cm x 1 cm in size. Near one of the occurrences 2 km southeast of Moose Lake, aplite dikes in the granite gave 10 times background total count readings on a BGS1 scintillometer.

An occurrence of pyrite and malachite hosted by brecciated and altered Moose Lake granite was located in 1981 on the south side of Gales Brook 1.7 km northeast of the Sops Arm road. The mineralization occurs in a gently dipping, quartz rich, shear zone 10 cm x 1.5 m in dimensions. This showing was originally discovered by H.R. Peters (personal communication, 1981) some twenty years ago.

POTENTIAL

Dolostone and minor limestone beds in the Lower Volcanic formation and in the Simms Ridge Formation encircle the northern part of the Gull Lake intrusive suite and are considered potential targets for skarn-type mineralization.

Potential for bulk tonnage, low grade gold deposits exists in the felsic volcanics of the Sops Arm Group. Most of the sericite alteration is concentrated in the Lower Volcanic formation close to the Doucers Valley Fault Complex. In most places it is accompanied by minor disseminated pyrite mineralization. Altered units discovered in 1981 will be assayed for gold and silver.

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THE SOUTHERN CONTACT OF THE ACKLEY GRANITE,
SOUTHEAST NEWFOUNDLAND; LOCATION AND MINERALIZATION

by

W.L. Dickson

The southern contact of the Ackley Granite was mapped in detail in two areas to precisely locate its position (Maps 1, 2, 3) and to follow-up whole rock geochemical anomalies (Colman-Sadd *et al.*, 1981). The main mineral showings in the Rencontre Lake area occur within the granite adjacent to the contact. Similarly, between Gisborne Lake and Rally Pond, many small showings of molybdenite, fluorite, pyrite, and hematite and numerous quartz veins and pods, and large dikes of an unusual rock type known as quartzolite occur close to the margin of the granite. (Quartzolite is an igneous plutonic rock which contains 90% or more quartz and less than 10% feldspar, IUGS classification). Rock geochemical anomalies for Sn, F, U, Mo and Li are also concentrated near the margin in the Rally Pond - Gisborne Lake area (Dickson, in prep.).

BIG BLUE HILL POND AREA

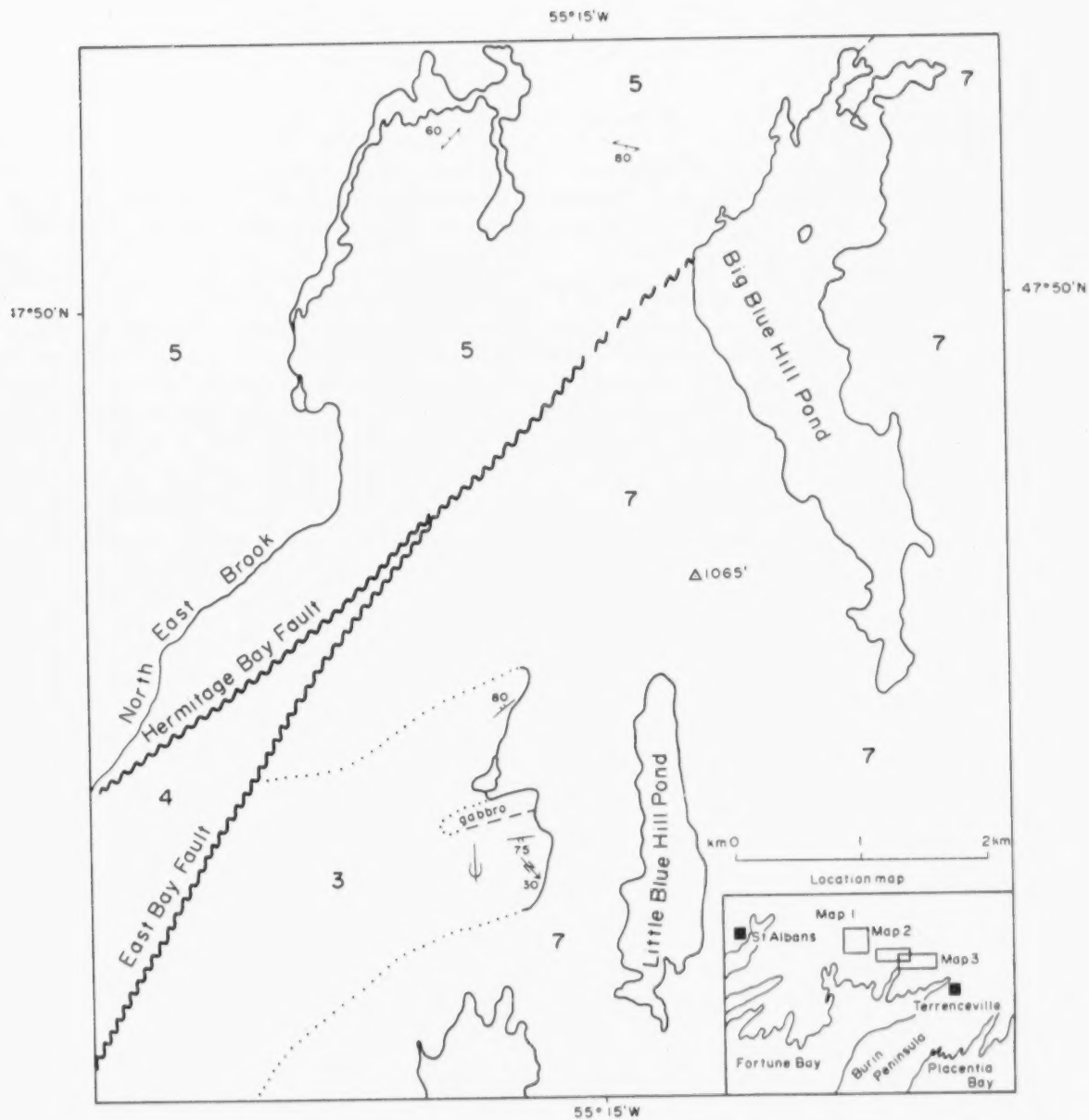
The contact of the Ackley Granite in the Big Blue Hill Pond area (Map 1) was found to be located further to the west than previously shown (Anderson, 1965). The contact with the Cambrian and older(?) Youngs Cove Group is well exposed in several places and is vertical. Numerous large (>10 m) screens of Youngs Cove Group sandstone occur within the granite up to 200 m from the contact. Near the southeastern corner of the Youngs Cove Group, west of Little Blue Hill Pond (Map 1), large granite dikes also cut the sandstones and form a mixed zone up to 200 m wide. The Youngs Cove Group in the area forms a sequence of easterly trending, steeply dipping, thinly to thickly bedded, generally massive, rusty sandstones and siltstones which have been deformed to form small folds. Contact metamorphism has produced

randomly oriented muscovite and fresh brown biotite. The feldspars show variable alteration to sericite. Pyrite is common in the sediments and where weathered gives the rusty appearance to the rocks. The Youngs Cove Group is cut by a 200 m thick vertical gabbro dike which has been contact metamorphosed by the Ackley Granite to an assemblage of tremolite - actinolite, plagioclase, epidote and magnetite, with relict augite in the cores of some of the amphibole crystals.

The Ackley Granite, in the Big Blue Hill Pond area, shows three main textures. The most common variety of granite is coarse grained, equigranular, biotite granite which is locally cut by fine grained, porphyritic dikes of granite. This latter type also underlies sizeable areas and typically contains small phenocrysts of quartz, orthoclase perthite and plagioclase in a fine grained granite matrix. The third variety of granite lies to the northwest of Little Blue Hill Pond and is medium grained, slightly porphyritic, biotite granite and is texturally and mineralogically identical to the coarse grained granite with a hypidiomorphic granular texture. The mineralogy consists of quartz, orthoclase perthite, plagioclase (An_{15}), biotite and minor magnetite, apatite and zircon. All varieties of granite in the area are slightly altered with secondary hematite and sericite. No economic minerals were found in the area.

RALLY POND AND GISBORNE LAKE AREA

The Ackley Granite contact with the Precambrian formations between Rally Pond and Gisborne Lake (Maps 2 and 3) is generally well defined. Only areas west



Map 1. Geological map of the Ackley Granite contact in the Little Blue Hill Pond area

LEGEND

DEVONIAN

- 7 ACKLEY GRANITE: Mainly medium grained, miarolitic, slightly porphyritic, biotite granite; minor, undivided, coarse grained, equigranular biotite granite.
- 6 CROSS HILLS GRANITE-DIORITE COMPLEX: 6a, Metagabbro and diabase; 6b, medium grained, biotite-hornblende granodiorite and granite.

SILURIAN-DEVONIAN

- 5 NORTH WEST BROOK COMPLEX: Foliated, medium grained, biotite + muscovite granite with minor older, foliated, coarse grained, porphyritic, biotite granodiorite; minor screens of Ordovician or older metasediment.

?ORDOVICIAN OR OLDER

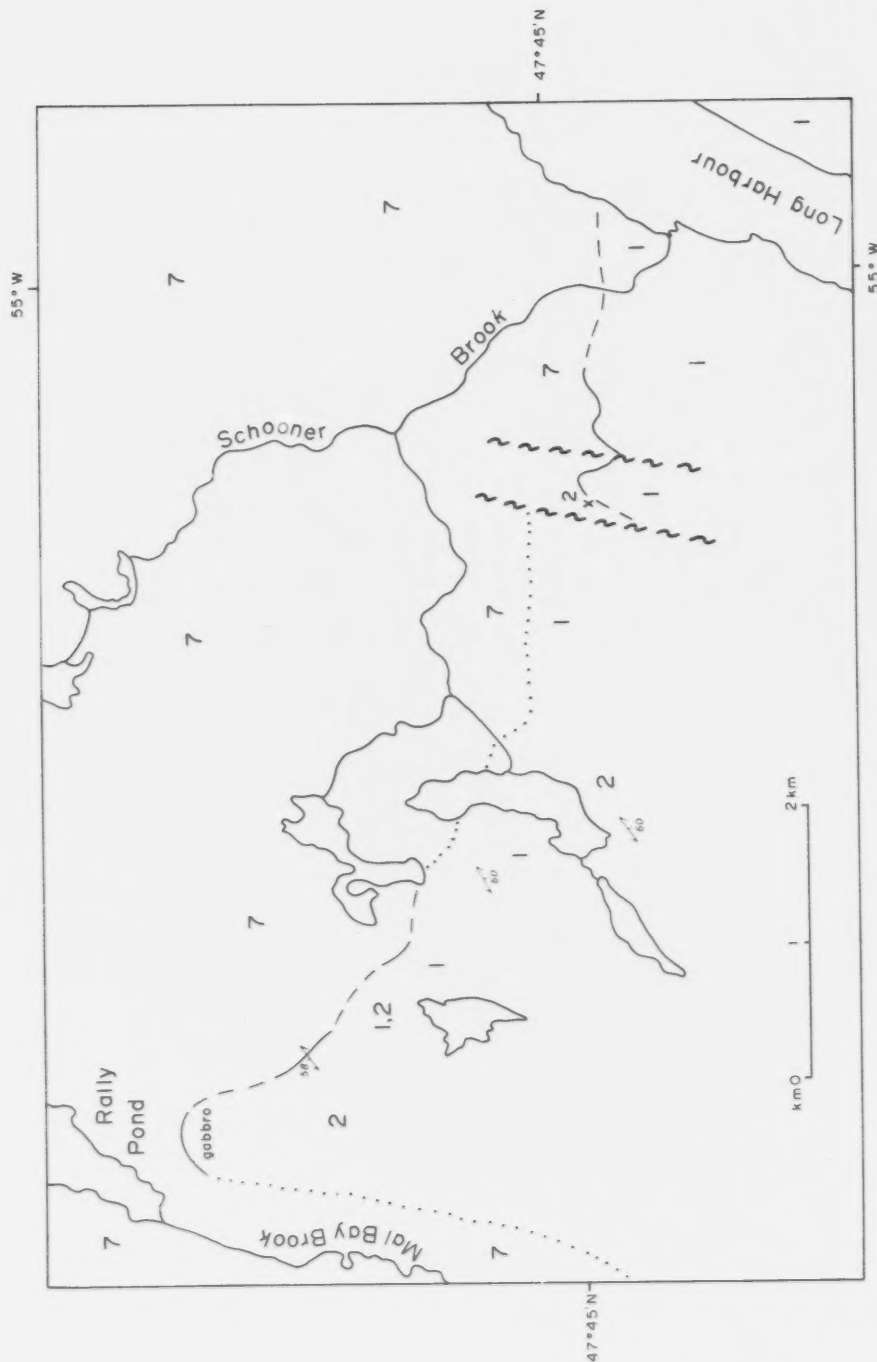
- 4 SIMMONS BROOK BATHOLITH: Medium to coarse grained, gray granodiorite and diorite.

CAMBRIAN AND OLDER

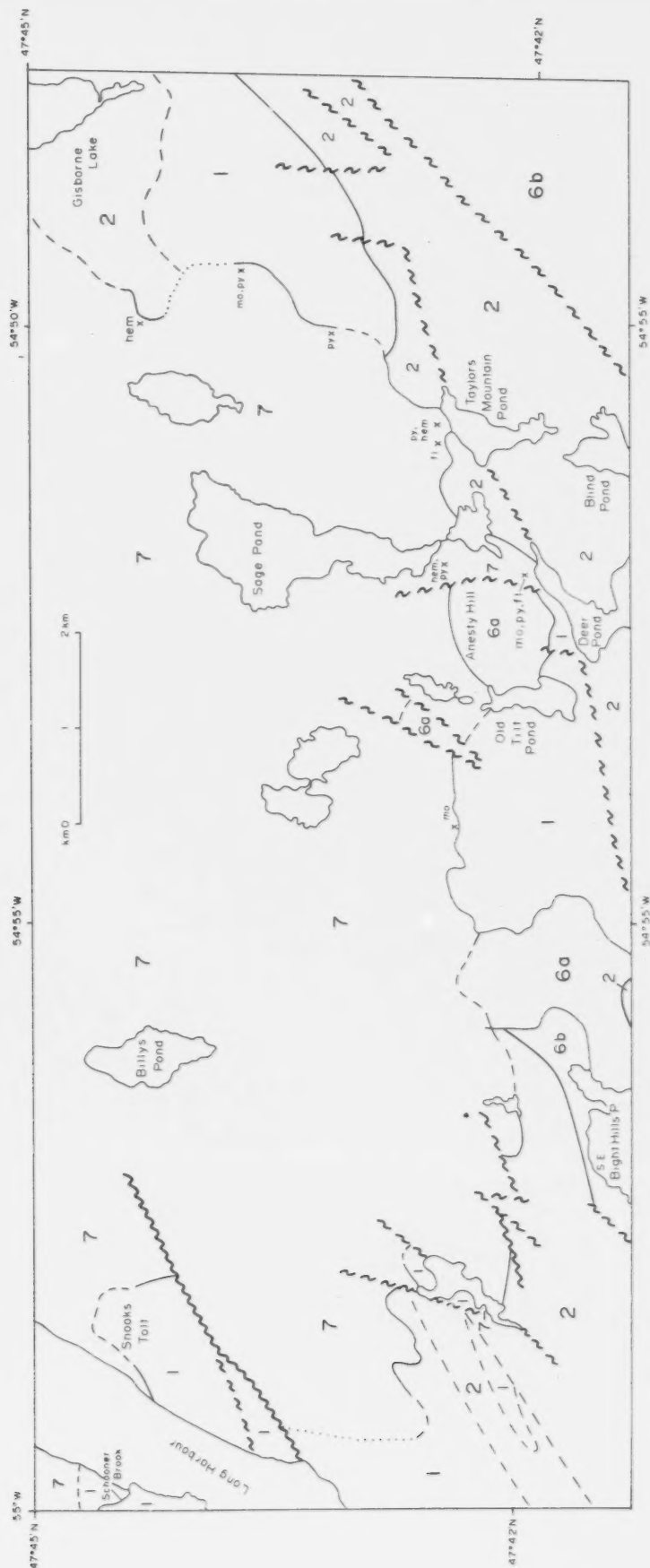
- 3 YOUNGS COVE GROUP: Dark and light gray, micaceous sandstone; hornfels.

LATE PRECAMBRIAN

- 2 ANDERSONS COVE FORMATION: Unseparated gray, green and minor red, terrigenous sediments: includes minor undivided mafic flows.
- 1 BELLE BAY FORMATION: Predominantly volcanic breccias, ash flow tuffs, flow layered rhyolite and basalt flows; minor unseparated gabbro.



MAP 2. Geological Map of the Ackley Granite contact between Rally Pond and Long Harbour



MAP 3. Geological map of the Ackley Granite contact between Long Harbour and Gisborne Lake

of Schooner Brook, southwest of Snooks Tolt, and southwest of Gisborne Lake are poorly defined due to lack of exposure. The contact is exposed in several places but usually there is a small gap in exposure. The contact is everywhere near vertical. The contact is modified in places by small unexposed cross faults. South of Snooks Tolt the effects of faulting on the rocks are apparent. Along the trace of the fault, which has been eroded to form a deep gorge, the granite is highly jointed and locally contains subhorizontal slickensides which trend parallel to the fault trace. In other areas topographic lineaments with apparently abrupt changes in the trend of the contact are attributed to the small cross faults.

Rare xenoliths of rhyolite and sandstone from the Precambrian formations were found within the granite but always close to the contact.

The Precambrian sediments and volcanics have been contact metamorphosed by the Ackley Granite to produce a hard hornfels in a narrow aureole up to 200 m in width. The hornfels consists of a recrystallized assemblage of quartz, feldspar, muscovite and biotite, and rarely andalusite and possibly staurolite in the metasediments. Dikes and veinlets of granite rarely cut the volcanics and sediments and usually penetrate only a few metres into the country rock. However, dikes of quartz-feldspar porphyry, which may be related to the Ackley Granite, occur throughout the Belleoram map area (Williams, 1971).

The Ackley Granite varies from coarse to medium grained, equigranular, biotite granite in the vicinity of Rally Pond and Gisborne Lake to fine grained, equigranular to slightly porphyritic, biotite granite towards the south. An important factor is the altitude of the contact, which appears to control the width of the zone of fine grained granite. Along Schooner Brook and Long Harbour, which are at sea level, the

zone of fine grained granite is about 200 m wide. On higher ground west of Schooner Brook and underlying most of Map 3 southeast of Snooks Tolt, the zone of fine grained granite is up to 4 km wide. The transition from fine to coarse grained granite is gradual with a few dikes of fine grained granite intrusive into the coarse grained granite in the Long Harbour - Gisborne Lake map area (Map 3). However, in the Rally Pond - Long Harbour map area, dikes of fine grained porphyritic granite, which cut coarse grained granite, are abundant.

The apparent increase in width of the zone of fine grained granite may be due to proximity to the roof or margin of the batholith. The presence of miarolitic cavities, tuffisites, and granophyric textures shows that the granite is high level. Similarly, a plot of normative $Q:Ab+An:Or$ for this unit of the Ackley Granite (Unit 14, Dickson, 1980) shows a concentration of points near the ternary minima of Tuttle and Bowen (1958) for 0.5 and 1 kb P_{H_2O} and the 1 kb minimum at An_3 of James and Hamilton (1969). Thus, a change in altitude of 250 m clearly could have a significant effect on the crystallization of the granite. A similar high level origin for the petrogeneses of the various granite phases and molybdenite prospects at Rencontre Lake 12 km southwest of Rally Pond is proposed by Whalen (1980). It is clear, therefore, that this phase of the Ackley Granite formed at a very high level and very close to the roof.

Quartzolite dikes, quartz veins and pods, hematite-quartz veins and zones of highly altered granite occur within the granite close to the contact with the country rocks and are most abundant in the Sage Pond area (Map 3).

The quartzolite dikes are probably a very late stage differentiate of the marginal phase of the Ackley Granite. The dikes are discontinuous and rarely more than 15 m in length and 5 m in width. The dikes are resistant to

weathering and commonly form low, smooth, glacially polished ridges which weather white and are commonly pink, red or white on fresh surfaces. The quartzolites have a hypidiomorphic granular texture with abundant quartz and interstitial, highly sericitized, feldspar and locally abundant pyrite and fine grained fluorite.

MINERALIZATION

In a few localities southeast of Anesty Hill, molybdenite occurs in the several quartzolite dikes. However, the molybdenite occurrences are very small and probably do not exceed 0.1% MoS₂. The occurrences are described in McLachlan (1953) and Rickets and Bumgarner (1954) who did not consider the showings to be economic for molybdenite. Trace molybdenite occurs in pyrite bearing quartzolite, 2.5 km east of Sage Pond, close to the contact with rhyolitic volcanics.

Quartz veins and pods are common along the margin of the granite. They are generally small and rarely exceed 2 m. The veins consist of coarse anhedral quartz crystals with minor inclusions of feldspar and sericite.

About 2.5 km west of Anesty Hill, coarse 5 to 20 mm, locally abundant molybdenite flakes occur in numerous small pods in veins of quartz over an area of about 100 m². The quartz occurs in coarse grained, equigranular granite within 100 m of the contact with Precambrian basic volcanics. The proportion of molybdenite is overall less than 0.1% in the quartz veins.

Specular hematite-quartz veins of varying sizes were found near the margin of the granite east of Sage Pond. The veins are composite in places with texturally distinct fine grained hematite-quartz adjacent to coarse grained hematite with well formed quartz crystals. Fine grained granite is also found mixed with the hematite. Thin veinlets of hematite also occur in some

quartzolite dikes. Analysis of a thin section of coarse grained, hematite-veined quartzolite, 400 m north of Taylors Mountain Pond, indicated the presence of trace amounts of cassiterite. The cassiterite occurs as 0.5 mm, subhedral, interstitial crystals with variably developed simple twins and one crystal is zoned. The proportion of cassiterite in the thin section is less than 0.1% of the mode.

Highly altered grey granite is located east of Anesty Hill. The alteration occurs in narrow zones 1 to 2 m in width and up to 10 m in length. The altered granite locally contains fluorite and hematite, and is highly sericitized. Only quartz is left of the original minerals. This rock is probably a griesen.

The granite in the Anesty Hill area contains the highest whole rock tin value of 242 g/t (Colman-Sadd *et al.*, 1981). Samples of granite from the contact zone between Gisborne Lake and Rally Pond contain most of other high tin values. Additional samples of quartz veins, quartzolites, hematite veins, altered granite, molybdenite bearing samples from the Wylie Hill and Motu molybdenite prospects, and the adjacent fresh granite from each locality have been collected and analysed for major elements and tin. The results are presented in Table 1.

Major elements show that the host granite is highly differentiated with high SiO₂ and very low MgO and CaO. The molybdenite bearing granites have a very high SiO₂ content which may be partly due to alteration which has depleted the Na₂O content of the granite. Secondary coarse muscovite and highly altered small plagioclase phenocrysts are common. Whalen (1980) suggests that silicification of the mineralized granites has occurred.

The altered gray granite (analysis 221153) shows a severe depletion of Na₂O and pronounced depletion of K₂O and a

TABLE 1: MAJOR ELEMENT AND TIN ANALYSIS OF SAMPLES FROM THE SOUTHERN MARGIN OF THE ACKLEY GRANITE

SAMPLE NO.	221148	221149	221150	221151	221152	221153	221154	221155
ROCK TYPE	GRANITE	HEM. VEIN	GRANITE	QUARTZO-LITE	GRANITE	ALTERED GRANITE	GRANITE	QUARTZ VEIN
SiO ₂	77.6	87.6	78.6	85.5	77.7	84.5	76.7	90.5
Al ₂ O ₃	11.85	2.15	11.65	9.90	12.00	8.70	12.55	4.83
Fe ₂ O ₃	.57	8.33	1.28	.40	.98	1.25	.29	.06
FeO	.44	.12	.14	.02	.13	.43	.48	.21
MgO	.09	.05	.04	.03	.12	.13	.10	.04
CaO	.21	.10	.13	.52	.30	.16	.27	.19
Na ₂ O	3.24	.35	3.55	.39	3.10	.44	3.46	1.88
K ₂ O	4.79	.88	4.54	.73	4.78	2.87	4.86	.60
TiO ₂	.21	.06	.13	.12	.25	.24	.16	.17
MnO ₂	.13	.11	.03	.01	.02	.20	.03	.02
P ₂ O ₅	.01	.01	.01	ND	.01	.01	ND	ND
LOI	.47	.39	.37	1.02	.55	1.35	.71	.40
TOTAL	99.51	100.15	100.47	98.64	99.84	100.28	99.61	98.90
Sn g/t	9	177	23	16	8	221	12	11
SAMPLE NO.	21156	21157	21158	21159	21160	21161	21162	21163
ROCK TYPE	GRANITE	QUARTZ VEIN	GRANITE	QUARTZ VEIN	WYLIE HILL GRANITE	WYLIE HILL GRANITE	MOTU GRANITE	MOTU GRANITE
SiO ₂	75.6	96.6	77.2	96.8	81.1	76.3	80.8	81.5
Al ₂ O ₃	12.85	1.03	12.45	1.15	10.30	13.15	11.20	10.35
Fe ₂ O ₃	.46	.06	1.10	.08	.30	.61	.36	.17
FeO	.84	.12	.02	.10	.81	.50	.14	.20
MgO	.05	.02	.07	.02	.08	.16	.06	.05
CaO	.33	.09	.25	.08	.19	.19	.18	.23
Na ₂ O	3.81	.23	3.57	.29	2.61	2.77	2.83	2.61
K ₂ O	4.98	.25	5.27	.27	4.29	4.07	4.75	4.41
TiO ₂	.11	.02	.08	.01	.15	.17	.15	.14
MnO ₂	.05	.01	.03	.01	.01	.01	.02	.02
P ₂ O ₅	.10	.03	ND	ND	.02	ND	ND	.01
LOI	.63	.22	.36	.16	.68	1.25	.52	.40
TOTAL	99.81	98.68	100.40	98.97	100.54	99.19	101.01	100.09
Sn g/t	6	2	2	2	6	30	6	3

Analyst: H. Wagenbauer, Department of Mines and Energy

corresponding decrease in Al_2O_3 and increase in SiO_2 and FeO and Fe_2O_3 .

Tin values for the hematite vein, altered granite, quartzolite samples and its host granite, and a molybdenite bearing granite from Wylie Hill are enriched compared to the background values for tin in the area. However, the background is also high with a mean value for tin in the Long Harbour - Gisborne Lake area of 13 g/t. The tin content of the altered granite is significantly enriched compared to its host rock (analysis 221152). The mineralogy of the altered granite is quartz, sericite, fluorite, and specular hematite, and is similar to that found in greisen associated with the Cornwall tin deposits, apart from the apparent absence of tourmaline in the altered granite. However, trace amounts of tourmaline occur in samples collected in the Long Harbour - Gisborne Lake area.

The molybdenite mineralization in the quartz veins and quartzolite dikes clearly formed during late stage crystallization of the marginal facies of the Ackley Granite (see also Whalen, 1980). The original feldspar within the quartzolite dikes has been completely altered to sericite. The dikes also contain up to 2.5% F with visible fluorite (O'Brien, personal communication, 1981). Thus, the quartzolites may have formed by hydrothermal alteration of aplite dikes. The tin mineralization probably formed during crystallization of the aplites as both the quartzolite and granite are enriched in tin in this area.

The greisen of the granite is a late hydrothermal event which has introduced tin, fluorine, iron and manganese, and depleted sodium, potassium and aluminum.

The formation of the greisen and the alteration of the aplites to form quartzolite may be related hydrothermal events.

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BASEMENT - COVER RELATIONSHIPS AND PLUTONIC ROCKS
IN THE MAKKOVIK SUBPROVINCE, NORTH OF POSTVILLE
COASTAL LABRADOR (13J/13, 130/4)

by

Bruce Ryan and Alex Kay

INTRODUCTION

Geological mapping of the eastern part of the Labrador Central Mineral Belt, north of Postville (13J/13, 130/4) was completed during the 1981 field season. This work, along with the earlier projects of Bailey (1981), Gower (1981) and Ryan (in preparation) and the ongoing project of Ermanovics (in preparation), has now covered the whole of the Makkovik Subprovince (Taylor, 1972) at 1:100,000 scale. Previous regional reconnaissance surveys in the area have been conducted by the Geological Survey of Canada (cf. Douglas, 1953; Christie *et al.*, 1953; Kranck, 1953; Stevenson, 1970; Taylor, 1979) and BRINEX (Morrison, 1958; Gandhi, 1969). In addition, BRINEX and Placer Development have carried out more detailed studies of the coastal strip along the northwest shore of Kaipokok Bay (Sutton, 1971a, 1971b; 1972; Burns, 1980), in the vicinity of Salmon Pond (Griep, 1977) and at a small uranium showing at the head of Kaipokok Bay (Lever and Davidson, 1978). Results from these surveys were often at variance with each other (*e.g.* the 'mylonite' of Sutton is shown as 'felsic tuff' by Burns) and no consistent regional picture emerged. The aim of this project was to resolve some of the inconsistencies, and compare the geological evolution of the area with that established in the adjacent parts of the Makkovik Subprovince. The results of

this survey agree most closely with those of Sutton (1971a, 1971b; 1972), but modifications have been made based on observations outside his project area, and these may have far-reaching implications with regards to the evolution of the Makkovik Subprovince as presently understood for this area (cf. Marten, 1977).

The area (Figure 1) comprises predominantly quartzofeldspathic and mafic gneisses referred to as Makkovik gneiss*, supracrustal rocks of the Aphebian Aillik Group, and granitoid rocks of the Aphebian Island Harbour Bay+ (Bay of Islands) plutonic suite. Brief descriptions are presented here, but more detailed information will be available in the notes accompanying the 1:50,000 scale maps for the area (Ryan, Kay and Ermanovics, in preparation).

MAKKOVIK GNEISS

The term 'Makkovik gneiss' has been suggested by I.F. Ermanovics (personal communication, 1981) to encompass the gneisses which occur in the Bay of Islands (Island Harbour Bay) area, and will be retained here to include all the gneisses occurring in this part of the Makkovik Subprovince. These rocks have had a long deformational and metamorphic history, and probably include both Archean and Proterozoic components. An Archean age for parts of the complex is suggested by comparison with the Nain

* Makkovik gneiss is used as an informal term. We recognize that this will need revision in compliance with the Code of Stratigraphic Nomenclature.

+ Island Harbour Bay plutonic suite will be used herein to avoid confusion with the Bay of Islands Complex in western Newfoundland and to conform with the terminology of Ermanovics and Korstgaard (1981).

ARCHEAN	PROTEROZOIC (APHEBIAN)		
	Ailik Group	Island Harbour Plutonic Suite	Coarse biotite granite Gray granodiorite Diorite, hornblendite
			Granite Gabbro, diorite
		lower	Mafic and felsic tuff
Makkovik gneiss	upper	Garnetiferous pelitic gneiss Amphibolite Gray psammite Actinolite schist, pillow lava, banded tuff, minor quartzite	
		Mylonitic amphibolite Zone of intensely mylonitized gneiss and granite "Younger" migmatite Megacrystic foliated granite "Straightened gneisses", where meta-Kikkertavak dikes are parallel to layering	
		Anorthosite Amphibolite "Older" migmatites and gneisses, cross cut by meta-Kikkertavak dikes	

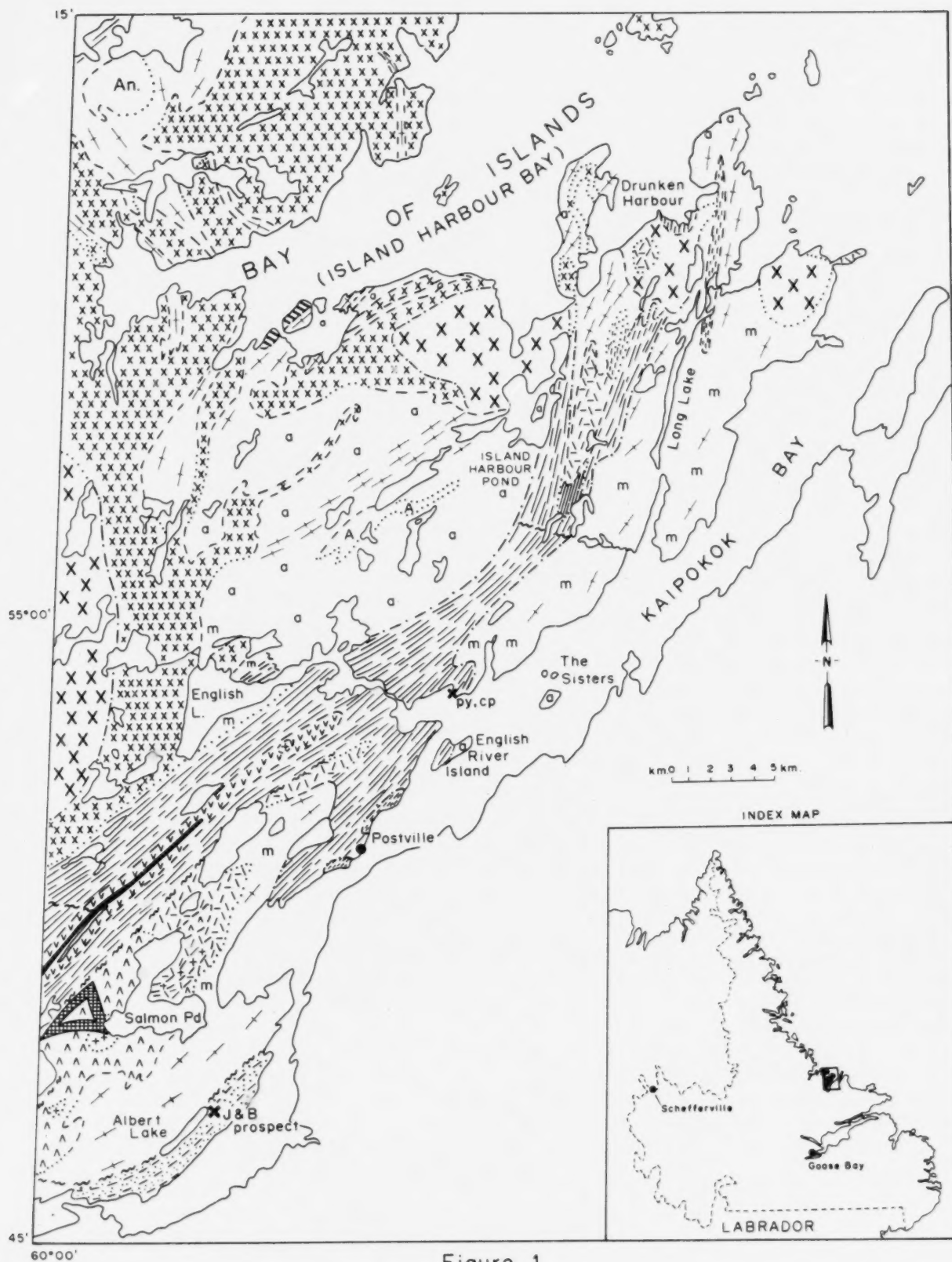


Figure 1

province to the northwest, based primarily on the relationship of metamorphosed diabase dikes to gneissic layering. These amphibolite dikes are correlated with the late Archean - early Proterozoic Kikkertavak dike swarm of the Kanairiktok Bay area (Ermanovics, personal communication, 1981), and where they still display a discordance to a gneissic layering, the layering is considered Archean. Where both the amphibolites and gray gneisses are parallel as a result of subsequent 'straightening', the layering is considered to be Proterozoic. The most extensive area of rocks with discordant dikes occurs north of English Lake, but other smaller areas occur around Bay of Islands. However, most of the area is characterized by 'straightened' gneiss and migmatite in which the metamorphosed dikes occur as parallel layers in a more leucocratic host.

PRE-DIKE ROCKS

Rocks which are clearly intruded by amphibolitized Kikkertavak dikes comprise migmatite, amphibolite and anorthosite, the anorthosite constituting a large enclave in straightened gneiss northwest of Bay of Islands (Island Harbour Bay).

The migmatites (Plate 1) are characterized by an irregular granite vein network which pervades a discontinuously layered gray to pink biotite gneiss. Isolated pods and inclusion trains of amphibolite and hornblende, with rarer anorthositic gabbro, are present locally.

Migmatitic and quartz veined, locally layered, pyroxene bearing amphibolite is interleaved with the early migmatites north of English Lake.

Gabbroic anorthosite and related rocks outcrop as an ovoid intrusion approximately 10 km northwest of Bay of Islands (Island Harbour Bay). It comprises recrystallized, sugary textured, gray to white weathering

anorthosite and gabbroic anorthosite, amphibolitic metagabbro and layered ultramafic rocks.

THE DIKES

The amphibolite dikes (Plate 1), in contrast to the gneisses which they intrude, are not migmatitic. They are dense, massive, black to green weathering rocks which are locally plagioclase porphyritic.

POST-DIKE ROCKS

Gneisses throughout most of the area are well layered gray granodioritic rocks with parallel or slightly discordant massive amphibolite units (Plate 2). These are considered to be derived by Hudsonian structural reorientation of the gneiss/dike relationships described above. In contrast to the migmatitic character of the Archean gneisses, these younger gneisses are well layered rocks with little internal disruption. Exceptions occur along the west shore of Kaipokok Bay where a wide zone of younger migmatite occurs, and adjacent to the Island Harbour Bay plutonic suite where contact migmatization is extensively developed.

The 'straightened' gneisses are regularly layered and the alternating mafic and felsic layers are continuous along strike for many tens of metres. In places, the reworking appears to have occurred under an intense mylonitic regime, for feldspars and quartz have been tailed out, pegmatites are disrupted to isolated rounded pods, and rootless intrafolial folds are common.

In the Drunken Harbour area, elongate, foliated, megacrystic, biotite granites, having slight discordance to the gneissic layering, are interpreted to have been emplaced synchronously with the 'straightening' event. K-feldspar phenocrysts up to 5 cm in length impart a pronounced L>S fabric to these rocks.



Plate 1: Openly folded metadiabase (amphibolite) dike in early migmatites, Bay of Islands. Lower half of photo comprises multiphase granodiorite of Island Harbour Plutonic Suite.



Plate 2: "Straightened gneiss". Reworked early migmatite and meta-diabase dikes, Bay of Islands. Island Harbour granodiorite at left.

The 'straightened' gneisses are considerably migmatized along the western shore of Kaipokok Bay north of Postville. The gneissic layering in the paleosome is disrupted and convoluted and the amphibolites commonly occur as isolated rafts. The neosome is a gray, granodiorite, somewhat similar to the earliest phases of the Island Harbour Bay plutonic suite.

REFOLIATED MAKKOVIK GNEISS

A pronounced north-northeast trending zone of mylonitization, with gradational boundaries, up to 10 km wide overprints all the earlier gneissic structures west of Kaipokok Bay. The zone comprises gray to pink, quartzofeldspathic and green amphibolitic rocks, ranging texturally from tightly folded and transposed gneisses to flinty ultramylonites (Plate 3). Deformed granites are recognized locally (*cf.* Sutton, 1972).

AILLIK GROUP

Metasedimentary and volcanic rocks of the Aillik Group outcrop west and southwest of Salmon Pond and southeast of Albert Lake.

Strongly deformed mafic and intermediate volcanics and psammitic metasediments of the lower Aillik Group (Marten, 1977) occupy a tight synform within the refoliated (mylonite) zone. Predominant are strongly schistose, ribbed weathering actinolite metabasites of uncertain protolith in which quartz stringers parallel the foliation. Locally, zones of relict primary structures can be recognized indicating that the protolith to the metabasites was gabbro, bedded tuff, volcanic breccia and pillow lava. Minor amounts of banded gray quartzite (metachert?) have also been observed with the metabasites. Metasedimentary rocks, varying from biotite schist to andalusite-bearing, thinly bedded psammities, occupy the central portion of the belt and structurally overlie the metabasites.

Southwest of Salmon Pond, similar lithologies occur as an intimate part of the gneiss complex. Here, the metabasites are hornblende rather than actinolite bearing, and the psammitic metasediments are represented by garnet- and muscovite-bearing lithologies.

A faulted wedge of upper Aillik Group (Marten, 1977) occurs at the head of Kaipokok Bay. These comprise buff to green weathering, interlayered mafic and felsic tuffs, with lesser amounts of gray porphyritic rhyolite and dense, green mafic flows and/or sills.

GABBRO AND DIORITE

Elongate bodies of gabbro and diorite occur mainly within the mylonite zone between Salmon Pond and Drunken Harbour. They are generally fresh, subophitic textured, medium grained rocks, but are locally pegmatitic. Margins may be foliated and metamorphosed, but the interiors are massive except for narrow shear zones. A pink to white weathering granitic dike network intrudes the gabbro locally.

GRANITE

A granitic network locally dissects the gabbros, and at Salmon Pond granite occurs as a discrete elongate intrusion cutting the gabbro and amphibolite (Griep, 1977). It is medium grained, weakly foliated, locally sparsely porphyritic and contains biotite $\pm$ hornblende.

ISLAND HARBOUR BAY PLUTONIC SUITE

The Island Harbour Bay (Bay of Islands) plutonic suite is a multiple intrusion dominated by gray granodiorite and pink granite (Ermanovics, 1980). In the map area the granodiorite is the more abundant phase.

The gray granodiorite occurs as a marginal phase and is well developed around the Bay of Islands (Island Harbour Bay), where it exhibits a



Plate 3: Finely laminated mylonite from refoliated gneiss zone near Postville.



Plate 4: Comb-layering in diorite dikes, Bay of Islands.

lit-par-lit migmatitic relationship with, and contains abundant rafts of, the country rock gneisses. The granodiorite is a very fine to medium grained sphene-rich rock which has at least four components varying from dark, biotite-rich diorite to leucocratic granodiorite. It is massive or weakly foliated. It may also display well developed igneous layering and is, in places, porphyritic.

Two of the islands and adjacent mainland along the south shore of the Bay of Islands (Island Harbour Bay) display large ultramafic to dioritic rafts within the granodiorite, which appear to be remnants of an appinite association. The diorite locally occurs as dikes in the hornblendite and metadiorite. These dikes display spectacular development of comb-layering formed by prismatic hornblendes nucleated normal to the dike walls (Plate 4).

The interior phase of the Island Harbour intrusion west of English Lake comprises coarse, pink to gray, biotite granite. This phase also occurs as gently dipping sheets along the south shore of the Bay of Islands (Island Harbour Bay). It is sparsely porphyritic and north of Island Harbour Pond contains euhedral perthitic orthoclase megacrysts up to 6 cm in length.

POSTTECTONIC MINOR INTRUSIONS (NOT SHOWN ON SKETCH MAP)

The area contains abundant subhorizontal, commonly red weathering diorite dikes. They are generally 1 m thick. Thicker dikes are locally present, and these may display crude compositional layering.

Coarsely porphyritic diabase dikes are present in places. These are steeply dipping, brown weathering, fine to medium grained rocks, characterized by large (several centimetres in size) phenocrysts and glomerocrysts of plagioclase.

A few narrow, black lamprophyre dikes were noted along the south shore of Bay of Islands (Island Harbour Bay) and the west shore of Kaipokok Bay.

Rhyolitic dikes have also been noted in a few areas. Narrow, gray, quartz-feldspar porphyry dikes cut the gneisses at Bay of Islands and English Lake. At the former locality, they predate intrusion of the early gray phase of the Island Harbour Bay plutonic suite. A 30 m thick, pink, quartz-feldspar porphyry dike intrudes the Archean amphibolite northeast of English Lake. Homogeneous fine grained rhyolitic dikes are present in the vicinity of Long Lake.

Pegmatites are locally present in the border zone of the Island Harbour Bay plutonic suite. They contain quartz, feldspar (albite, microcline, amazonite), biotite, muscovite, beryl, garnet and fluorite.

STRUCTURE

All rocks, except the posttectonic minor intrusions show a foliation, and a polyphase deformational Archean and Proterozoic history is apparent.

The relationship of amphibolite dikes to the rocks they intrude indicate that the Archean gneisses and layered amphibolites have undergone at least two deformational episodes and a period of migmatization before dike intrusion.

After intrusion of the dikes, the gneiss/dike complex was subjected to several periods of Hudsonian deformation and metamorphism. In zones of low deformation, where discordance to layering is preserved, the dikes may be folded (Plate 1); stretched plagioclase phenocrysts and a hornblende lineation are apparent. Outside, these low deformation augen, the reworked gneiss/dike complex displays a regular layering, in places mylonitic, and exhibits a moderately south-plunging mineral lineation. This lineation is

also apparent in foliated megacrystic granites in the Long Lake area. Locally both gneissic layering and lineation are folded, a feature which appears to have predated development of Hudsonian migmatites in the Long Lake area.

An intense zonal mylonitization is superimposed on the Hudsonian migmatites, and it too is a poly-deformational feature. Outside the present map area this zone is continuous with the refoliated gneisses at the Aillik/gneiss contact mapped by Marten (1977) on the southeast shore of Kaipokok Bay (Figure 2). In the margins of the zone an early mylonitic gneissosity is overprinted by a younger mylonite fabric which is the dominant fabric in the zone. In many places the younger fabric is of L>>S type, and the generally shallow southerly plunge of the lineation gives rise to rocks which exhibit a finely foliated or banded aspect on horizontal outcrop surfaces (Plate 3), but which show their original character on surfaces normal to the lineation.

The dominant foliation in the mylonite zone is also the foliation present in the lower Aillik Group confined to this zone. The lower Aillik Group occurs as a southwest plunging synform west of Salmon Pond and is directly correlative with Marten's Post Hill synform (Figure 2). Both the Aillik Group rocks and the mylonite have been refolded about northeast trending axes, and either due to original variable plunge of the supracrustals or plunge of the refolding structure, the supracrustals are not continuous around this structure. The northeast-trending Witch Lake slide (Figure 2) may be related to subvertical translation during this phase of deformation. The Island Harbour Bay plutonic suite and the gabbros in the mylonite zone and near Salmon Pond may have been intruded before this late folding episode for both are locally weakly foliated. The deformation itself may in some way be related to late structural adjustments following

intrusion of the Island Harbour Bay pluton. A domal structure in the gneisses north of English Lake (Figure 2) may also be a consequence of this, but the relative age of this particular fold structure has not been established.

The deformational chronology from the Makkovik Subprovince then, is indicative of at least two locally recognizable periods of folding during the Archean (Kenoran Orogeny), and further polyphase deformation and metamorphism during the Aphebian (Hudsonian Orogeny). Two Hudsonian deformational episodes predated a migmatization event, and further zonal deformation (mylonitization) and folding was superimposed on this migmatite. The zonal mylonitization and concomitant infolding of the Aillik Group is equivalent to Marten's (1977) D_1 - D_2 event, and the subsequent refolding on northeast-trending axes as shown in Figure 2 corresponds to his D_3 .

ECONOMIC GEOLOGY

The most significant known mineral occurrence in the area is the J & B Prospect (Lever and Davidson, 1979). This is a zone of anomalous radioactivity in sheared rhyolitic tuffs and associated mafic flows or sills of the upper Aillik Group near Albert Lake. The zone is generally less than 2 m wide and occurs intermittently along strike for 1.5 km. The host rocks are epidotized and hematized, and the mineralization appears to be largely structurally controlled along the sheared contact between felsic and mafic bands.

Radioactivity has also been reported from the migmatitic gneisses in the area of Long Pond (Morrison, 1958; Sutton, 1971a; Burns, 1980). This is confined to pegmatites and is due to the presence of U-Th-REE bearing minerals such as allanite, crystals of which may reach several centimetres in length.

A pyritic gossan with minor chalcopyrite occurs in mylonitized

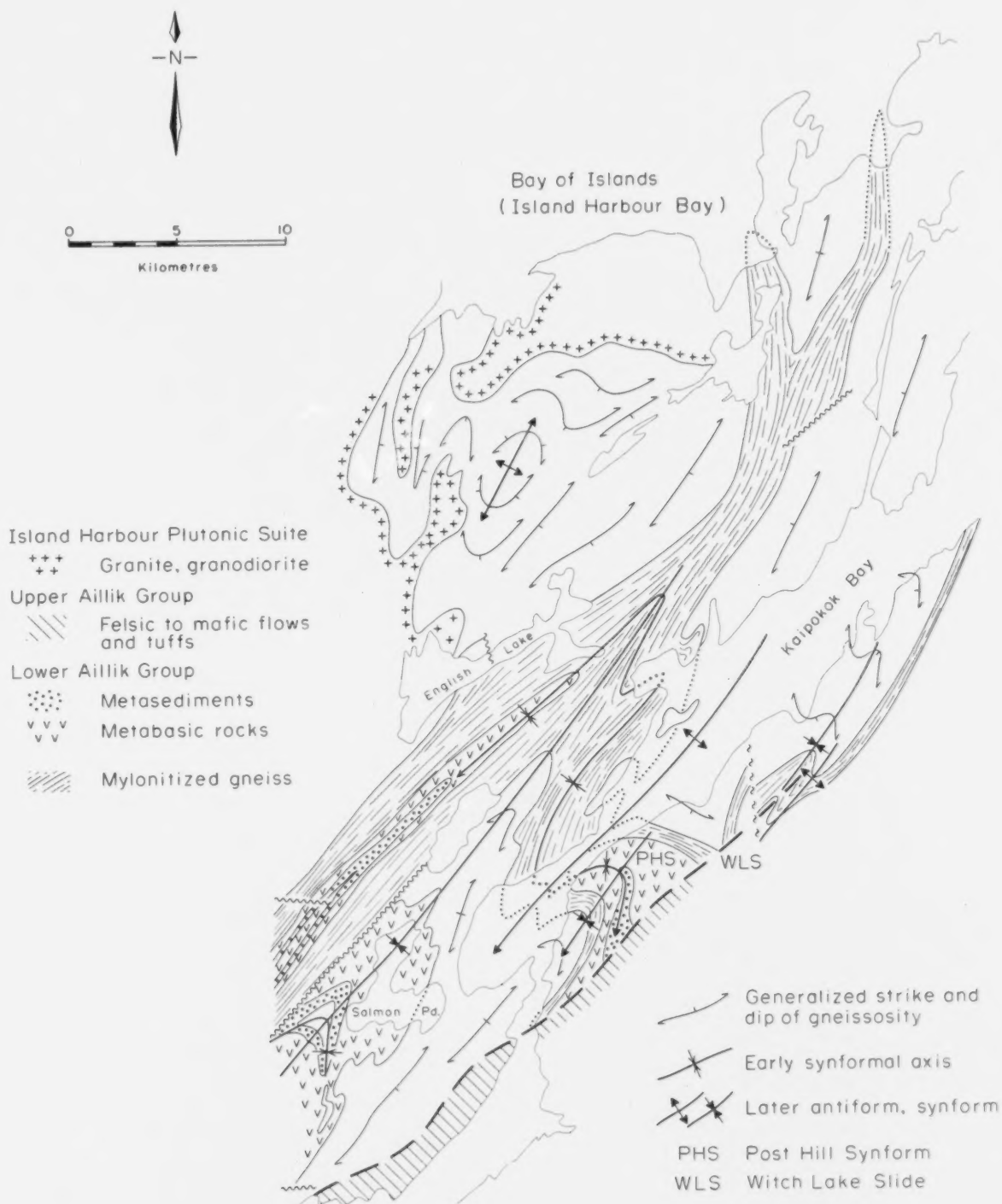


Figure 2: Correlation of map units and structures across Kaipokok Bay

gneiss and gray granite on the coast north of English River Island. Smaller rusty pyritic zones are found within the gabbro intrusions.

A small fluorite showing was documented by Morrison (1958) from coarse granite west of Drunken Harbour and fluorite was observed microscopically in the same granite north of Island Harbour Pond.

RELATIONSHIPS OF THE AILLIK GROUP TO THE GNEISSES

Relationships between the gneisses and Aillik Group have been discussed by Sutton (1972) and Marten (1977). These studies have concluded that the gneisses around Kaipokok Bay (referred to by them as the Hopedale Complex) represent the Archean basement on which the Aphebian Aillik Group was deposited. The unconformity between the two was obliterated by intense subhorizontal and later subvertical translation (tectonic sliding) along the basement-cover interface which led to the development of a well defined mylonite (slide) zone at the gneiss-Aillik contact. This mylonitic deformation was attributed to the Hudsonian Orogeny, but it was considered that the migmatitic gneisses outside the zone of reworking were Archean in age.

This study also supports the existence of a mylonite (slide) zone between the lower Aillik Group and migmatites but questions the age of migmatization. If the correlation of the discordant metadiabase dikes of the Bay of Islands area with the late Archean - early Proterozoic Kikkertavak dikes of the Nain Province is valid, then the amphibolite facies metamorphism which overprints them must be Proterozoic (Hudsonian) in age. This metamorphism was accompanied by structural reorientation of the dikes and an earlier migmatite banding, such that throughout most of the map area the parallel gray gneiss-amphibolite layering is a combination of the earlier

gneissosity plus dikes, which have been structurally reworked during the Hudsonian. It is these 'straightened gneisses' which comprise the paleosome to the migmatites of the 'Hopedale Complex' around Kaipokok Bay, and therefore this migmatization must be an even younger Hudsonian event.

Marten (1977) concluded that the earliest penetrative fabrics recognizable in the Aillik Group could be related to the mylonite (slide) zone which overprints the migmatites and separates them from the Aillik, and therefore these fabrics represent the initial penetrative effects of the Hudsonian Orogeny on the cover. If this is the case, and the migmatites are themselves a product of the Hudsonian, then the pre-mylonitic Hudsonian metamorphic and structural history of the gneisses is missing from the Aillik Group in the area of Marten's study.

The same conclusion with regards to the deformation in the lower Aillik Group and the enclosing mylonites west of Salmon Pond can be drawn from this study since the fabric in the mylonite is also the fabric of the supracrustals and metamorphic grade in both is upper greenschist - lower amphibolite. However, south of Salmon Pond, higher grade metavolcanic and metasedimentary rocks correlated with the lower Aillik Group appear to be an intimate part of the middle amphibolite facies gneiss terrain. There is no slide (mylonite) zone present in this area and the contact between the quartzofeldspathic gneisses and supracrustal rocks is apparently a gradational one in which amphibolite layers become increasingly abundant in the gneisses towards the metavolcanics (Griep, 1977). If this is a slide zone as well, it does not have the fine mylonitic fabric so characteristic of the other slide zone at the gneiss/Aillik interface. The foliation in the gneisses and the supracrustals appears to be the same age, and therefore, it would seem that the Aillik Group in this area has been subjected to

the same history as the surrounding gneisses. How then can we explain both the presence of Aillik Group in a middle amphibolite facies gneiss terrain and the occurrence of lower grade Aillik Group in a mylonite (slide) zone which overprints these same gneisses?

Marten has suggested that the present disposition of the Aillik Group and the migmatitic gneisses along the southeast shore of Kaipokok Bay is the result of a modified unconformity between Aphebian cover (Aillik Group) and Archean basement (migmatites of the "Hopedale Complex"). This is implausible if the migmatites themselves are Hudsonian. In addition, the relationships described from south of Salmon Pond would suggest that the Aillik Group had been deformed and metamorphosed concomitant with the development of the gneisses. Why then does the history of the Aillik Group in slide contact with the migmatites show no record of the earlier events? Conceivably, the intense penetrative deformation associated with the mylonitization has obliterated any vestiges of these earlier events in the cover. However, the preservation of bedding and other primary features of the supracrustals in the mylonite zone indicates that they have not been subjected to any higher grade metamorphic and deformational episodes. An alternative explanation may be that the Aillik Group, bounded by slide zones, is highly allochthonous and has undergone much later deep-level tectonic slicing into a terrain which had already been subjected to migmatization earlier in the Hudsonian. The lower grade assemblages of Aillik rocks adjacent to and within the slide zones would suggest this, and therefore imply that the Aillik Group in these zones was far removed, either laterally or vertically from their present site when this migmatization occurred.

The above interpretation implies that the Makkovik Subprovince has had a much longer metamorphic history than previously suspected. However, this conclusion becomes invalid if the amphibolite dikes of the area are not

Kikkertavak equivalents and the supracrustal rocks south of Salmon Pond are not Aillik Group. A geochronology program focusing on these problems is presently underway.

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THE GEOLOGY OF THE CARTWRIGHT REGION

LABRADOR

by

C.F. Gower, V. Owen, & G. Finn

INTRODUCTION

Reconnaissance mapping at 1:100,000 scale conducted in the Cartwright region during the 1981 field season covered a 10,000 km² area extending from the Mealy Mountains to the Labrador Sea between latitudes 53°30' and 54°00'. This work concludes a stage of 1:100,000 reconnaissance mapping in the Grenville Province in eastern Labrador, completing mapping east of longitude 59° and north of latitude 53°30'.

PREVIOUS WORK

Early work in the region was done by Daly (1902), Christie (1951), Taylor (1951), Kranck (1939, 1953) and Douglas (1953). Their work was confined to coastal exposures but they delineated the main rock types present in the region; namely, gneiss, granite, amphibolite, gabbro and anorthosite. Most of the early work in the interior was done by Brinex (Piloski, 1955; Sutton, 1965; Bradley, 1966) in selected areas. Much of this work was done outside the area shown in the sketch map, although some investigations were conducted at the south end of Sandwich Bay. The first regional geological map of the area was completed by Eade (1962) who defined most of the major rock types in the area. 1:100,000 mapping was done by Cherry (1978a, b) in the Sandwich Bay area and the area north of North River was mapped by Gower *et al.* (1981).

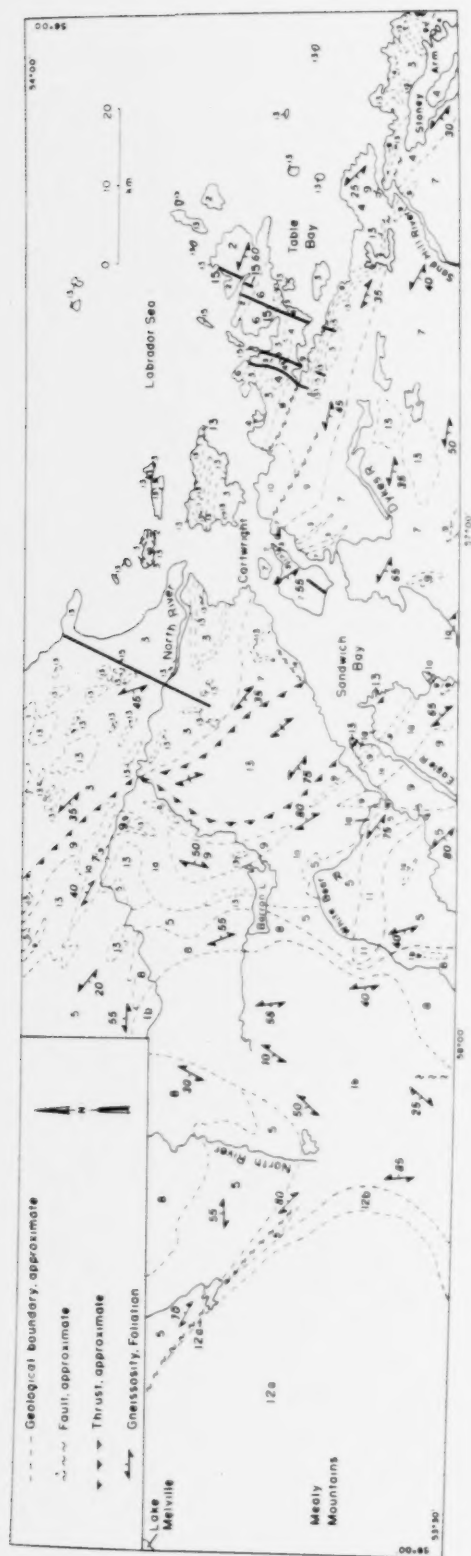
No absolute age data are available for any major unit within the region although ages are available for two Paleozoic dikes (Grasty *et al.*, 1969; Wanless *et al.*, 1970).

APHEBIAN? (UNITS 1 & 2)

Units 1a, 1b and 2 include a range of upper amphibolite facies metamorphic rocks interpreted as paragneisses. Unit 1a in its least metamorphosed form comprises brownish weathering psammitic gneiss interlayered with irregular zones of pelitic gneiss, minor quartzite, pyritic layers and rare calc-silicate horizons. More typically, it is an inhomogeneous diatexite consisting of a restite of biotite + garnet + sillimanite + opaque mineral enveloped in a pink quartzofeldspathic neosome. In places, the restite is evenly dispersed as ovoid patches in the neosome giving a mottled appearance to the rock and scant resemblance to its original meta-sedimentary protolith.

Unit 1b has a similar mineralogy to Unit 1a but more commonly has the appearance of a well banded granitic gneiss. In places the gneiss grades into an irregularly banded rock with pink granitic pegmatoid neosome associated with biotitic schlieren. On the basis of (i) sillimanite observed in some outcrops, (ii) a characteristic (of paragneisses) mauve-coloured garnet, and (iii) extrapolation from paragneiss associated with common quartzite in the lower English River area, these rocks are also interpreted as paragneisses.

Unit 2 comprises muscovite-biotite and biotite - garnet + muscovite schists and gneisses with the muscovite rich rocks being particularly schistose. From preliminary examination of a few thin sections, kyanite is seen to be a common additional phase and sillimanite absent. The less schistose rocks have a 'knotty' appearance related to a black restite



LEGEND

- PALAEZOIC**
15. Gabbro, olivine gabbro and diabase dikes.
- HADRYAN**
14. Conglomerate with abundant gabbroid and gneissic clasts (cf Double Mer Formation)
- HELIKIAN (cf ELSONIAN?)**
13. Gabbro, leucogabbro, diabase, some monzonite and syenite; amphibolite in part.
12. **Maly Mountains Intrusive Suite.**
- a. Anorthosite, leucogabbro, minor monzonite.
- b. Granite, alkali feldspar granite, some monzonite.
11. Leucocratic, medium grained, feldspar garnet rock with minor hornblende, quartz and chlorite (recrystallized anorthositic gabbro?).
- HELIKIAN (cf KETILIDIAN?)**
10. Coarse grained monzonite, recrystallized in part, massive to foliated.
9. Medium to coarse grained, generally megacrystic biotite granodiorite, augen gneiss in part, foliated to gneissic.
8. Medium to coarse grained, seriate textured biotite and hornblende quartz monzonite to granodiorite.
7. Medium to coarse grained, biotite hornblende diorite to quartz diorite, amphibolitic in part.
- HELIKIAN AND/OR APHEBIAN?**
6. Medium grained, melanocratic, extremely garnetiferous diorite grading to amphibolite, some could be deformed equivalent of Unit 13.
- APHEBIAN?**
2. Kyanite muscovite garnet biotite schist and gneiss (metatectites). Paragneiss.
1. a. Sillimanite garnet pelitic schists and gneiss, (homogeneous and inhomogeneous diatexites). Minor quartzite and rare calc silicate layers. Paragneiss.
- b. Sillimanite bearing, garnetiferous granitic gneisses similar to 1a.
3. Medium grained, biotite tonalite to granodiorite gneiss. Discontinuously to well banded, migmatitic.
4. Medium grained biotite hornblende quartz diorite granodiorite, migmatitic. Possibly gradational into Unit 3.
5. Medium grained biotite granodiorite gneiss. Hornblende bearing in part, some amphibolite enclaves.

composed of biotite + opaque minerals enclosed within a pink quartzofeldspathic neosome and both subsequently intensely folded. Irregular, muscovite bearing alaskite dikes and muscovite + tourmaline bearing pegmatites intrude Unit 2. These are partially discordant to compositional layering in the gneiss, and hence later, but a spatial association is unequivocal.

Units 1 and 2 are believed to be among the earliest rocks in the area and possibly of Aphebian age, though no age data are presently available. Both may well have been derived from similar metasedimentary protoliths though the presence of quartzite and psammite suggests a higher arenaceous component to Unit 1.

HELIKIAN AND/OR APHEBIAN (UNITS 3-6)

Unit 3 consists mostly of medium grained biotite tonalite to granodiorite with common amphibolite enclaves. Locally, the rock grades into quartz diorite or K-feldspar megacrystic granodiorite. Most of the tonalitic gneiss contains 5-30%, slightly coarser grained, creamy weathering leucosome generally concordant to the prevailing fabric. Hornblende is commonly an additional essential phase in the tonalitic gneiss and small garnets are ubiquitous.

There is unequivocal evidence that some of the gneisses are pre-Grenvillian, inasmuch as the gneissosity is truncated by gabbro sheets probably emplaced about 1400 Ma. It is unknown whether the gneissosity developed during the Hudsonian Orogeny or an earlier event. Clearly this rock is a good candidate for a basement on which the paragneisses were deposited. However, there is also good evidence that some of the tonalite/granodiorite gneisses are the product of Grenvillian reworking of (?Paleohelikian) granitoid rocks that probably postdate the paragneisses. This is partly a scale-of-mapping problem and could be resolved with detail work.

Unit 4 comprises homogeneous quartz diorite, quartz monzodiorite or granodiorite. The rocks are medium to coarse grained and though extensively recrystallized have suggestions of plutonic igneous texture remaining. Biotite and hornblende are essential mafic phases and small garnets are commonly also present. The rock has experienced incipient partial melting with about 5% leucosome developed. Amphibolite enclaves and light weathering microgranite minor intrusions are characteristic of the unit. Unit 4 is closely spatially associated with Unit 3 and may be either a less migmatized and deformed equivalent or a slightly younger plutonic rock emplaced into the gneisses.

Unit 5 includes a wide range of foliated and gneissic rocks with variable fabrics ranging from agmatite to nebulite and including some homogeneous granodioritic rocks. Gneissosity is accentuated by amphibolite enclaves and 5-30% leucosome. Biotite, hornblende and garnet are the usual mafic phases. Unit 5 is interpreted as a mixture of Hudsonian or older gneissic rocks and Paleohelikian granitoid rocks, both reworked during the Grenvillian Orogeny. The unit is closely comparable to Unit 3, but is presently distinguished because the overall assemblage appears to be granodioritic rather than tonalitic as well as being a more heterogeneous association of lithologies. Perhaps field differences can be ascribed to the fact that the unit occurs south of a major thrust fault system with correspondingly greater Grenvillian reworking.

Unit 6 is a weakly to strongly foliated, medium grained, recrystallized diorite with hornblende and garnet as essential mafic minerals. Abundant garnet (greater than 15%) is characteristic of the unit. Rarely, the diorite contains K-feldspar megacrysts. On the north side of Table Bay the diorite develops agmatitic features close to a gabbro body and then appears to be

gradational into the gabbro. This suggests that the diorite may be a deformed equivalent of the gabbro, in which case the whole unit is younger than its present stratigraphic position indicates. However, farther west, there are indications that the gabbro intrudes the diorite. Our preference is to group the diorite with the tonalite-granodiorite gneissic package with which it is spatially associated.

HELIKIAN (cf. KETILIDIAN) (UNITS 7-9)

Unit 7 is a medium to coarse grained hornblende diorite to quartz diorite with rare K-feldspar megacrysts. Irregularly developed leucosome (5-10%) gives the rock an agmatitic appearance in places and the heterogeneity is emphasized by lenses and layers of amphibolite. Where subsequently flattened, the rock has a banded gneiss appearance. An 'amphibolitic diorite' unit will be distinguished on 1:100,000 maps in areas of abundant amphibolite. On the west side of Sandwich Bay, the equivalent rock is pink weathering, in contrast to its normal black and white appearance, and gives the misleading impression that the rock is a monzonite or quartz monzonite. Stained slabs have demonstrated that the colour is attributable to hematite alteration - this can be correlated with retrograde effects along a major northeast trending fault in the area.

Unit 8 is a medium to coarse grained, pink, buff or orange weathering granitoid rock with a composition ranging from granodiorite to quartz monzonite, although in places it may approach granite or quartz syenite. The dominant mafic mineral is hornblende, but biotite is also present and garnet occurs sporadically.

Unit 9 is characteristically a weakly to strongly foliated K-feldspar megacrystic granodiorite. The megacrystic granodiorite east-southeast of Cartwright grades into a coarse grained alkali feldspar granite at Table

Bay and has a transitional southern boundary into the quartz diorite of Unit 7. In the Eagle River area, the megacrystic granodiorite grades into sparsely megacrystic and nonmegacrystic granodiorite. The rock is termed granitic augen gneiss by Cherry (1978a) who incorrectly shows the unit as trending north-south. Margins of the bodies are conformable with the enclosing paragneisses but a finer grained 'porphyry' texture at the border suggests an intrusive relationship. Biotite is the characteristic mafic mineral but small garnets occur in the groundmass. Deformational fabrics indicate very heterogeneous strain with the smaller bodies and narrow portions of larger plutons exhibiting extremely strained ribbon-like quartz and crushed feldspar. Enclaves of tonalitic gneiss within the megacrystic granite in the Table Bay area demonstrate age relationships with respect to Unit 3. Some enclaves contain pegmatite dikes discordantly intruding the gneissosity of the enclave with the dikes themselves truncated against the enclosing megacrystic granodiorite.

Although Units 8 and 9 are strongly foliated in places, they do not have a gneissic/migmatized appearance and are readily recognizable as plutonic intrusive rocks. These features, and the fact that the units occur as coherent bodies with relatively simple outcrop patterns lead us to interpret them as younger than Units 3-6. Megacrystic granodiorite shows a close spatial relationship with the paragneiss of Unit 1a. The obvious hypothesis, that they are S-type granites derived from the paragneisses, will be tested during future work.

HELIKIAN (cf. ELSONIAN) (UNITS 10-13)

Unit 10 is a coarse grained, massive to strongly foliated monzonite that occurs in one area east of Cartwright. The unit was originally delineated by Cherry (1978a) who described it as a coarse grained and

massive monzonite at the centre and fine grained and foliated at the margins. He notes the mineralogy as plagioclase, perthitic microcline, quartz, biotite, hornblende, orthopyroxene and clinopyroxene. Cherry describes the margin as gradational into poorly foliated garnetiferous granite and augen gneiss. We have grouped these latter rock types as part of Unit 9, but acknowledge that no well defined boundary between the two rock types exists. The dark gray weathering colour and coarse grained, massive appearance makes the unit lithologically similar to monzonites associated with the anorthosites. However, the spatial relationships and perhaps transitional boundaries suggests a genetic link with the megacrystic granodiorite of Unit 9, which is lithologically more comparable to Paleohelikian granitoid rocks. These alternatives and the possibility of a continuum of Paleohelikian-Elsonian plutonism will be examined during future work.

Unit 11 is the most poorly exposed and least understood rock type in the area. It is a medium to coarse grained, leucocratic, recrystallized, feldspar-garnet rock with minor hornblende, quartz and chlorite. From limited stained slabs it appears that the feldspar is mainly plagioclase. The composition suggests an anorthositic protolith but, if this is so, it is texturally dissimilar from other anorthositic rocks in the region.

Although the Mealy Mountains Intrusive Suite (Unit 12a, b) has been included in the geological sketch map, only the eastern margin was examined, as the suite is the subject of more detailed work by Emslie (in preparation). An obvious distinction has been made between coarse grained, pink weathering, massive alkali feldspar granite (Unit 12b) and gray-brown weathering rocks ranging from monzonite to anorthosite (Unit 12a). This distinction was previously recognized by Emslie (1976) who referred to the border

unit (12b) as pyroxene quartz monzonite.

Unit 13 embraces a range of medium to coarse mafic intrusive rocks that includes gabbro, leucogabbro, pyroxenite, monzonite and locally syenite. Most of these were probably intruded as subhorizontal sheets except for the mass extending northwest from Sandwich Bay which appears to be a larger layered mafic intrusion. The sheets commonly show layering on scales ranging from less than 1 cm to tens of metres. Particularly good examples are present on Grady Island where layered units consist of a lower olivine gabbro/gabbro which is transitional over less than 2 m into an upper monzonite/syenite. Similar syenites were recognized by Gower *et al.* (1981; Unit 11), who noted a spatial association between syenite and gabbro. The syenites are beneath gabbro sheets and it is now clear that they are merely the upper portions of underlying layered units. The petrography of the gabbros along the coastline has been described by Taylor (1951).

HADRYN IAN

A new occurrence of post-Grenvillian conglomerate (Unit 14) identical to the Double Mer Formation (Kindle, 1924; Stevenson, 1970) was found on the northwestern side of Sandwich Bay. The conglomerate comprises rounded to subrounded boulders of gneiss, granite and gabbro up to 1 m diameter in a pebbly matrix of similar material. As with other areas, the unit is confined by faults, in this case a major northeast trending structure parallel to the northwest side of Sandwich Bay.

PALEOZOIC

A series of north-northeast trending gabbroid dikes (Unit 15) are well exposed on the coast east of Cartwright and some were previously mapped by Eade (1962). Their distribution can be clearly seen in coastal

areas from aerial photographs and further delineated using associated aeromagnetic anomalies. The dikes are vertical and range from a few metres to over 100 m in width. Wanless *et al.* (1970) report an age of 544 ± 22 Ma (K/Ar, biotite) from a dike on the west side of Hare Harbour and Grasty *et al.* (1969) have dated a dike from Shag Island (not shown on the map - 21 km north of Cartwright) as 505 ± 8 Ma (K-Ar, whole rock). The latter dike is described as fresh, coarse grained olivine gabbro with good ophitic texture - a generally applicable description.

SUMMARY OF MINOR MAFIC INTRUSIONS

There are several generations of mafic dikes most of which are too small to include on the sketch map. These are critically important in understanding the geological evolution of the area and it is now possible to present a preliminary synthesis. This is given in order of increasing age and goes beyond the Cartwright region.

(i) Mesozoic dikes and lamprophyres related to the opening of the Labrador Sea (*ca.* 150 Ma).

(ii) Paleozoic gabbro dikes with north-northeast trend (*ca.* 500 Ma).

(iii) Middle to late Grenvillian diabase dikes with trends either east-northeast or east-southeast (*ca.* 1100-950 Ma). The basaltic dikes intruding the Mealy Mountains Intrusive Suite dated at 1123 ± 50 Ma and 1078 ± 48 Ma (K-Ar whole rock) by Gittins (1972) are included in this group as are dikes which have a 1000-950 Ma age range from the Makkovik area (Gandhi *et al.*, 1969; Gower and Flanagan, in preparation), Unit 33 in the Benedict Mountains area (Gower, 1981) and numerous east-southeast trending dikes in both the Rigolet and Cartwright regions.

(iv) Layered mafic sheets which include pyroxenite, olivine gabbro,

leucogabbro, anorthosite, monzonite and syenite (*ca.* 1400 Ma). The term Michael Gabbro used informally by Fahrig and Larochelle (1972) who reported an age of 1457 ± 107 Ma, should be confined to this particular suite of intrusions. Alternatively the name should be discarded in favour of Shabogamo Intrusive Suite (1365 ± 60 Ma), (Brooks *et al.*, 1981), with which the rocks are almost certainly correlative. That they represent a hypabyssal phase of anorthosite magmatism was originally suggested by Kranck (1953).

(v) Net-veined, irregular and possibly rectiplanar dikes (*ca.* 1600 Ma). The net-veined and irregular form of many of the dikes is believed to be related to intrusion shortly after granitoid emplacement and before the granitoid rocks had completely crystallized. These dikes are best displayed on the coastline north of the Benedict Mountains but also occur within the Grenville Province on the coastline north of Groswater Bay and in southeast Sandwich Bay.

(vi) There may be another period of mafic dike injection after the emplacement of the Paleohelikian granites and before the Michael Gabbro. One outcrop on the south side of Groswater Bay shows evidence of three periods of mafic dike intrusion with all dikes metamorphosed and the youngest dike similar to Michael Gabbro. Other outcrops nearby show two intersecting dikes, both obviously pre-Grenvillian, both dissimilar from Michael Gabbro and both intruding granitoid rocks tentatively considered as Paleohelikian.

(vii) An outcrop of foliated to gneissic granodiorite in south Sandwich Bay contains two intersecting mafic dikes, the earlier isoclinally folded. These are intruded by a dike of megacrystic granite which is lithologically comparable to Unit 9 of this report. Assuming the megacrystic granite is Paleohelikian and that the lithological comparison is valid, this

implies that there are two pre-Paleo-helikian periods of mafic dike injection.

STRUCTURE AND METAMORPHISM

The regional structural trend is southeast except in the area east of the Mealy Mountains Intrusive Suite, where it progressively swings from southeast to south and then southwest approaching the Mealy Mountains. Folding in Units 1-6 is related to this southeast trend; characteristically, folds are tight to isoclinal and overturned to the north. Refolded folds are evident in places. Many axial surfaces are horizontal or dip south at less than 10° . Kranck (1953) described and sketched a typical recumbent fold in tonalitic gneisses east of Cartwright. Numerous tight, north verging folds are present in the inhomogeneous diatexites of Unit 1a at the south end of Sandwich Bay. These appear to be related to a southeast trending thrust exposed on the shoreline that separates the paragneisses from gabbroic rocks. The positioning of the northwest continuation of the thrust is based on aeromagnetic interpretation but correlates with a thrust indicated by Gower *et al.* (1981) farther north. The second thrust shown, on the north side of the gabbroid rocks, has not been seen but is interpreted from highly strained fabrics seen in Unit 7 immediately north of the thrust, as well as an obvious topographic lineament.

The deformation described above is the result of intermixed Grenvillian and pre-Grenvillian orogenic effects. The effects of deformation attributable to the Grenvillian Orogeny in Units 8 and 9 are rapid gradations from massive to cataclastic or mylonite fabrics.

Two periods of folding have affected the ca. 1400 Ma gabbros. The dominant fold trend is best seen on the islands north of Cartwright where wave lengths are 5-6 km and folds plunge shallowly west. The subsidiary trend is northeast and wave lengths are generally

less than about 100 m. The resultant effect, when combined with boudinage has been to disrupt the gabbro into huge, tilted and curved tablets with tonalitic gneiss remobilized between blocks and at gabbro/gneiss interfaces.

Numerous faults are present throughout the region, but to aid clarity only a few major structures are shown on the sketch map. Many of these are strike faults and their occurrence is based on observed brecciation and alteration rather than displaced lithological contacts. There is some evidence from aeromagnetic data that the fault bordering the Mealy Mountains continues southeast to link up with a series of faults in the Alexis River - Gilbert River region. Many of the faults are probably post-Grenvillian structures - this is certainly true of the northeast trending fault bordering the conglomerate on the northwest side of Sandwich Bay. Late stage calcite filled, north-northeast trending tension gashes are common at the south end of Sandwich Bay.

Metamorphic grade is at upper amphibolite to granulite facies with retrograde greenschist facies effects along fault and thrust zones. Eade (1962) has indicated that the rocks immediately east of the Mealy Mountains are of granulite grade. Plagioclase + K-feldspar + quartz + biotite + garnet + sillimanite + muscovite are the typical assemblages in Unit 1. Cherry (1978b) reported cordierite in some assemblages. Similar assemblages are present in Unit 2 except that kyanite, rather than sillimanite is present. The tonalitic, diorite and granodioritic rocks of Units 3-9 have mineralogies typical of igneous protoliths (with metamorphic fabrics) with the addition of garnet. Both garnet and hornblende occur as porphyroblasts and there is good textural evidence that they are the product of incongruent melting of the adjacent rock. Primary mineralogy is preserved in many gabbros though thin bodies and the margins of thicker units have been converted to

amphibolite, commonly garnetiferous or biotite rich.

ECONOMIC POTENTIAL

The paragneisses offer the highest economic potential. Numerous pyritic bands (with minor chalcopyrite) occur in the diatexites in the Eagle River area. Those observed were up to 3 m thick and traceable for 10-20 m along strike. Douglas (1953) mentioned malachite, chalcopyrite and bornite associated with quartzite in the lower Eagle River area. We observed a pyritic band associated with quartzite on the opposite side of the river which is probably the strike continuation. The pyritic bands gave no significant response when tested for uranium mineralization.

Malachite staining is also common in the muscovite rich schists of Unit 2 but pyritic layers were not seen. Tourmaline bearing, muscovite rich pegmatites are abundant in Unit 2 and merit rare earth prospecting. Minor molybdenite was found in pegmatite 18 km east of Cartwright.

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GEOLOGY OF THE CHURCHILL FALLS REGION

by

R.J. Wardle

INTRODUCTION

Three areas were studied in the summer of 1981, designated A, B, and C on Figure 1. Areas A and C were mapped in order to connect previous mapping in the Gabbro Lake and Churchill Falls areas (Rivers, 1981; Wardle and Britton, 1981) with projects in the East Michikamau Lake and Red Wine Mountains areas (Nunn, 1981; this report; Thomas *et al.*, 1981). Area B was the subject of a brief reconnaissance mapping project designed to investigate the nature of an apparently fundamental structural lineament extending through Ossokmanuan and Panchia Lakes.

The Churchill Falls Region lies at the junction of the Churchill and Grenville Provinces and is underlain largely by gneissic and granitoid rocks of Aphebian to Helikian age. All areas form part of an undulating plateau land extensively covered by lakes and a thick mantle of glacial drift. Exposure in all areas is extremely poor and mapping was carried out largely by helicopter, with limited ground traversing.

Previous mapping in areas A and C is limited to the Geological Survey of Canada work by Eade (1952). Although published at 1 inch = 2 mile scale, the mapping was more typical of reconnaissance 1 inch = 4 mile or 8 mile work, and gives only a very superficial account of the region. Area B is covered by 1 inch = 4 miles reconnaissance mapping of Stevenson (1969).

Access to the three areas is possible by unpaved road from the hydroelectric townsite of Churchill Falls. Construction of the Smallwood Reservoir, which includes Ossokmanuan, Gabbro, Lobstick and Michikamau Lakes has resulted in extensive flooding of

the plateau. The map for area C has been approximately corrected for this flooding, that for area B, however, has not.

AREA A - SONA LAKE (13E/12, E1/2)

The geology of this area is relatively simple (Figure 2) and consists of a southern unit of Aphebian(?) metasedimentary gneisses (Unit 1), and a northern unit of variably deformed Paleohelikian granitoid rocks (Unit 2). Both units are intruded by scattered gabbroid plutons (Unit 3).

UNIT 1 - APHEBIAN(?) METASEDIMENTARY GNEISSES

These rocks are typically pink, quartz-feldspar-muscovite-kyanite gneisses with accessory garnet, magnetite, and possibly ilmenite. They are usually massive in outcrop; compositional banding where seen is present only on a centimetre scale. The banding is usually isoclinally folded and crosscut by granitic and pegmatitic migmatite leucosome veins developed parallel to fold axial planes. Kyanite in the gneisses characteristically occurs as irregular bluish lenses 2-3 cm long which locally anastomose, imparting a flaser texture to the gneiss. Internally, the lenses consist of microcrystalline kyanite intergrown with biotite, muscovite and opaques. The gneisses also contain pods and boudins of biotite-amphibole schist or amphibolite, apparently the relicts of mafic dikes.

Associated with the kyanite gneisses are outcrops of gray to pink quartz-feldspar-biotite-muscovite gneisses, usually of massive appearance. The origin of these gneisses is not

certain, but the presence of muscovite and the association with kyanite gneisses suggests derivation from quartzofeldspathic sedimentary rocks.

The Unit 1 gneisses are continuous with the similar Disappointment Lake Gneisses described by Thomas *et al.* (1981), and Thomas (1981) from the area to the east. Radiometric dating in this area has indicated a minimum age of 1654 Ma for the gneiss (see Thomas, 1981) suggesting formation in an early Paleohelikian or late Aphebian orogenic event - probably related to the Hudsonian Orogeny. The depositional age of the gneiss protolith could be either Aphebian or Archean.

The contact of Unit 1 with the granitoid suite of Unit 2 has not been observed within Area A. To the west, however, identical gneisses are intruded by sheets of pre-tectonic aplite and granitoid of the granitoid suite. The Disappointment Lake Gneiss is also clearly intruded by plutonic rocks equivalent to Unit 2.

UNIT 2 - THE GRANITOID SUITE

Unit 2 underlies the northern two-thirds of the area and consists of a variety of tonalitic to granitic plutonic rocks. The earliest intrusive rocks are represented by scattered occurrences of fine grained, equigranular gray tonalite and granodiorite (2a). In one outcrop these have been intruded by aplite and granite dikes of Unit 2b.

Unit 2b is a heterogeneous assemblage of pink granite, quartz monzonite, aplite and microgranite, varying in texture from equigranular to porphyritic and probably representing several intrusive phases. Most of these granitoids are biotite bearing with minor hornblende and magnetite. The phenocryst phase is usually microcline. In the northern part of the area they are moderately foliated and preserve igneous textures; however, to the south,

they become increasingly foliated and eventually gneissic. Migmatization has affected these gneisses to a varying degree and has produced textures ranging from small isolated patches of granite mobilize, to lit-par-lit vein systems. Hornblende porphyroblasts are commonly present in the leucosome fraction. Unit 2c extends well to the east of the map area and is correlated with the North Pole Brook Suite described by Thomas *et al.* (1981). This has been dated at *circa* 1650 Ma (Thomas *et al.*, 1981).

Unit 2c is a coarse, pink, megacrystic quartz monzonite restricted to the northeast corner of the area. The unit is characterized by 2-3 cm diameter microcline megacrysts and rare plagioclase phenocrysts set in a coarse groundmass of K-feldspar, plagioclase, biotite and quartz. Magnetite is a common accessory. The unit locally appears gradational with the equigranular granites and quartz monzonites of Unit 2b and is probably genetically related to these rocks. Similar megacrystic monzonite occurs north and east of the map area and is part of an extensive pluton centered on Michikamau Lake (Nunn, 1981). The age of Unit 2c has been established by preliminary Rb-Sr dating at 1715 ± 100 Ma (Brooks, personal communication). However, this conflicts with a 1525 Ma age on volcanics intruded by the pluton (see Nunn and Noel, this volume).

UNIT 3 - GABBRO, METAGABBRO AND AMPHIBOLITE: MINOR PERIDOTITE

Small, pre-tectonic elongate stocks and dikes of gabbro have intruded Units 1 and 2. In the northern half of the area, the bodies are generally composed of fairly fresh olivine gabbro with ophitic or subophitic texture. In the southern part of the area, the smaller gabbro bodies and the margins of the larger bodies have been converted to hornblende-plagioclase-garnet amphibolites. The interiors of the larger bodies generally retain their ophitic texture. Recrystallization is

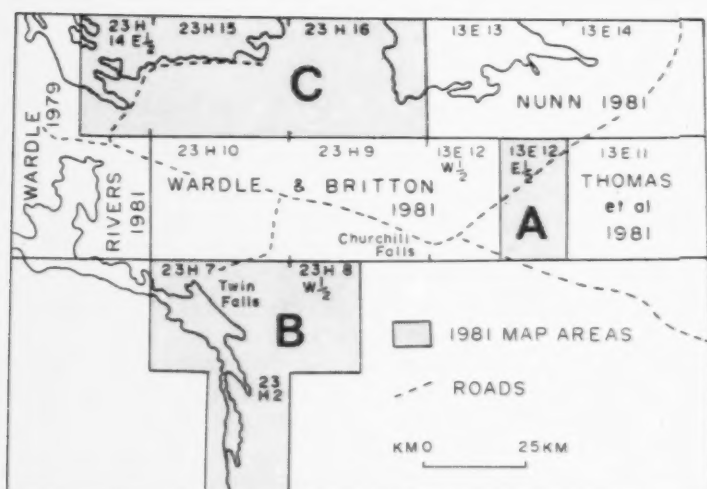


Fig. 1 INDEX TO 1981 MAP AREAS

LEGEND

PALEOHELIKIAN

- 3 Gabbro, metagabbro and associated amphibolite, minor peridotite
 - 3a - Diorite
- 2 Granitoid Suite
 - 2c - Pink megacrystic quartz monzonite
 - 2b - Pink equigranular granite, quartz monzonite, aplite and microgranite
 - 2a - Gray tonalite and granodiorite

APHEBIAN - ARCHEAN

- 1 Kyanite-muscovite bearing quartzofeldspathic gneisses

NOTE: Granitoid units south of line are gneissic and locally migmatitic in texture.

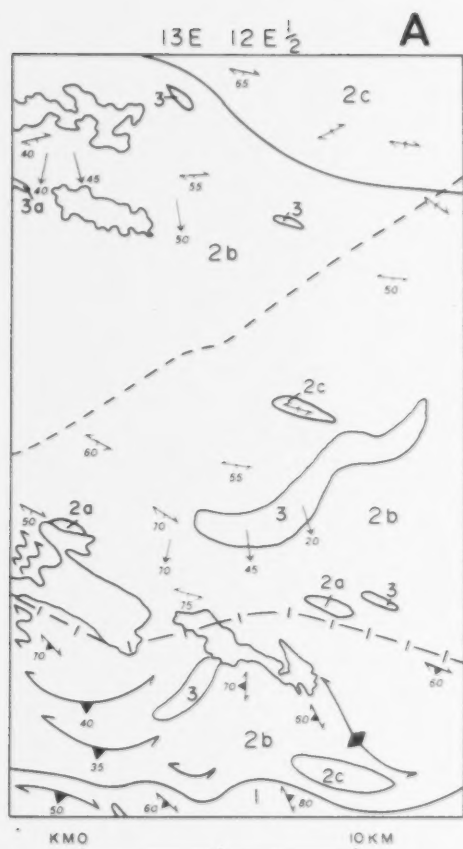


Fig. 2

limited to reaction rims of serpentine and actinolite around olivine and pyroxene, and growth of fine garnet in grain interstices. Peridotite has been noted at one locality within Unit 1.

One occurrence has been noted of a fine grained equigranular diorite (Unit 3a) comprising an alteration assemblage of actinolite, saussurite, biotite and opaques. The rock lacks the ophitic texture typical of the gabbros and may have originally contained primary amphibole.

The gabbros of Unit 3 are provisionally correlated with the Shabogamo Intrusive Suite of the Gabbro Lake area, dated at 1385 Ma (Brooks *et al.*, 1981).

STRUCTURE AND METAMORPHISM

The entire area has been affected by the Grenvillian Orogeny. Foliations and gneissosity produced during this event have undulatory east-west trends and steep southerly dips. Cataclastic fabrics present in the northern part of the area may be related to northerly

directed, high angle overthrusts. Open folding in the granitoid and Unit 1 gneisses is due to a late period of Grenvillian deformation about north-south axes. This fold generation generally becomes more intense to the south and west of the area (Wardle and Britton, 1981).

Metamorphic grade increases from greenschist facies in the north to middle amphibolite facies in the south.

The gneisses of Unit 1 have clearly been strongly metamorphosed together with the granitoid gneisses of Unit 2, presumably in the Grenvillian Orogeny. Evidence from the area to the east, however (Thomas, 1981), suggests a minimum age of 1650 Ma for the high grade metamorphism in the gneisses. It is possible, therefore, that these gneisses have been through a Hudsonian or early Paleohelikian event prior to granitoid intrusion and subsequent Grenvillian metamorphism. Any fabric evidence of this early event within the Sona Lake map area must have been obliterated during Grenvillian deformation and metamorphism.

AREA B - BAIKIE LAKE-PANCHIA LAKE AREA (23H7, H8W, H2)

Previous reconnaissance mapping (Eade, 1952) indicated a narrow belt of amphibolite, chlorite schist and garnet-biotite gneiss extending through Ossokmanuan and Panchia Lakes. In later compilation work by Greene (1970), this belt was inferred to separate a southwestern terrane of metasedimentary gneisses derived from Aphebian rocks; from a northeasterly terrane of gneisses derived from Helikian rocks. The possibility of a major structural break, or lineament, extending through the Ossokmanuan - Panchia Lake and Atikonak River system was supported by the regional aeromagnetic map (Geological Survey of Canada, 1974) which shows a pronounced contrast in aeromagnetic relief and trend across the lineament.

GENERAL GEOLOGY

As a result of the 1981 mapping (Figure 3) it is evident that the major part of the area is underlain by metasedimentary gneisses (Unit 1). These occur in two blocks separated by the Ossokmanuan Lake - Atikonak River lineament, and by a belt of granitoid gneisses (Units 2 and 3). Intrusive into both metasedimentary and granitoid gneisses are a series of gabbroid bodies related to the Shabogamo Intrusive Suite (Unit 4). A later series of granitic intrusions is represented by Units 5, 6 and 7.

The belt of mafic rocks mapped by Eade (1952) along Panchia Lake and Atikonak River could not be substantiated. The scattered exposures of gabbroid rocks which do occur along these waterways belong to small bodies of the Shabogamo Intrusive Suite and the major part of the waterway is apparently underlain by gneissic rocks of Units 1 and 2.

Unit 1 - Metasedimentary gneisses

The gneisses of this unit are similar in general field appearance to

those of Unit 1 in Area A, and are connected with that area by a belt of metasedimentary gneisses lying south of the Churchill and Unknown Rivers. Gneisses immediately south of the Unknown River in the northeastern corner of the area are kyanite bearing (1a) and pass southwards into sillimanite gneisses (1b). An approximate isograd has been drawn at the first appearance of sillimanite (Figure 2). However, metastable kyanite persists south of the isograd for several kilometres.

Muscovite bearing gneisses (1c) with minor fibrolite occur immediately south of Ossokmanuan Lake. Muscovite in these rocks is in arrested reaction with quartz to produce sillimanite (fibrolite) and K-feldspar. To the south, muscovite is absent and microcrystalline sillimanite is abundant. A further sillimanite isograd is therefore inferred to exist south of Ossokmanuan Lake.

The gneisses are apparently continuous with similar gneisses exposed to the west in the Labrador City area (Rivers, 1980, 1981). In this area the gneisses have been demonstrated to be equivalent to the Attikamagen Formation of the Aphebian Knob Lake Group (Labrador Trough); therefore, an Aphebian age is proposed for the Unit 1 protolith.

Unit 2 - Quartzofeldspathic gneisses of problematical origin

These rocks occur interspersed with the metasedimentary gneisses, and also as an isolated area of outcrop in the extensive drift covered areas east of Ossokmanuan and Panchia Lakes.

The gneisses are usually pink or gray weathering with the composition quartz-feldspar-biotite + hornblende and garnet. Microcline is occasionally present as scattered porphyroblasts. They lack any form of compositional banding and are usually migmatitic. Leucosome development is variable and ranges from small patches of incipient

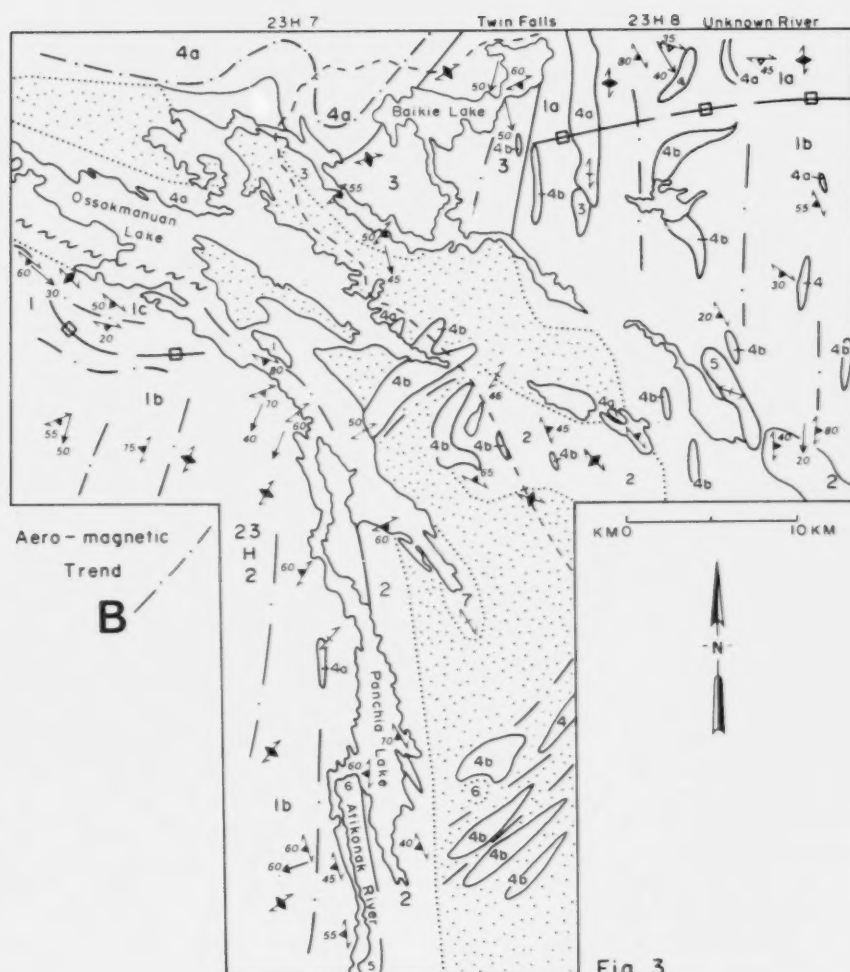


Fig. 3

LEGEND

NEO or PALEOHELIKIAN

- 7 Pink foliated granite
- 6 Foliated quartz diorite - quartz monzodiorite

PALEOHELIKIAN

- 5 Pyroxene bearing quartz diorite (enderbite)
- 4 Shabogamo Intrusive Suite
 - 4a - metagabbro - gabbro
 - 4b - anorthositic gabbro

- 3 Granodiorite - quartz monzonite granitoid gneisses

- 2 Quartz-feldspar-biotite gneiss of problematical origin

APHEBIAN

- 1a Kyanite gneiss; 1b, sillimanite gneiss; 1c, muscovite gneiss

 isograd

melt to lit-par-lit vein systems. Hornblende and biotite porphyroblasts are common in the leucosome veins. In thin section, the plagioclase is characteristically strongly antiperthitic; a feature that otherwise has only been noted in the pyroxene bearing granitoid of Unit 5. This feature, together with the massive nature of the gneisses, may indicate a plutonic origin for Unit 2. However, some of the pink quartzofeldspathic gneisses look identical in field appearance to the matrix of the sillimanite bearing gneisses and it is also conceivable that they may represent alumina deficient quartzofeldspathic gneisses of meta-sedimentary origin.

Unit 3 - Granodiorite - quartz monzonite granitoid gneisses

This is a uniform suite of gray weathering, quartz-feldspar-biotite gneisses exposed around Baikie Lake and the southern part of the Unknown River. These rocks have a predominantly granodioritic composition, ranging to quartz monzonite. Outcrop sections seen normal to lineation usually preserve relict feldspar porphyritic and seriate igneous textures. The gneisses are again variably migmatitic and commonly show two generations of leucosome; an early lit-par-lit banding developed parallel to gneissic foliation, and a later crosscutting banding parallel to axial planes of F_2 folds. Both generations are spotted with euhedral porphyroblasts of hornblende. Local merging of the two leucosome generations suggests that both were formed during one prolonged period of metamorphism, rather than two separate events.

In the vicinity of the south Unknown River the gray gneisses have been intruded by abundant pre-tectonic sheets of pink aplite and quartz monzonite gneiss. Some of these are possibly related to anatexis; however, the potassic intrusives are also very similar in appearance to a late granitic

suite noted in previous work to the north (Unit 9 of Wardle and Britton, 1981).

The contact between Units 2 and 1 follows the course of the Unknown River north of Baikie Lake. The contact has been the locus for considerable ductile shearing and flattening, but sheets of pink aplite and augen granite gneiss in Unit 1 suggest an original intrusive relationship.

Unit 4 - Shabogamo Intrusive Suite

The major intrusion belonging to this suite is located north of Ossokmanuan Lake and consists of fresh olivine gabbro (4a) with well developed ophitic texture. Pods of coarse grained pyroxene-plagioclase gabbro are common within this subunit and weak igneous layering is also locally present. The body forms a thick folded lacolith extending 25 km west of the area to Gabbro Lake (Wardle, 1979b; Rivers, 1981). Near its margins the gabbro has been converted to hornblende-plagioclase amphibolite.

In the remainder of the area, anorthositic gabbros are the predominant representative of the Shabogamo Intrusive Suite. These are distinctive, medium to coarse grained gabbros generally of pale gray appearance. Plagioclase forms euhedral 1-2 cm long laths and is intergrown in ophitic or subophitic texture with orthopyroxene, clinopyroxene and olivine. In most cases subsolidus cooling reactions have produced coronas of garnet and clinopyroxene around mafic grains. Coronas of serpentine around olivine have also been observed and are probably the result of metamorphic hydration.

Around the margins of these bodies the ophitic and corona textures have been destroyed and the rocks hydrated to coarse plagioclase-garnet-hornblende schists.

Unit 5 - Pyroxene bearing quartz diorite
(enderbite)

This unit occurs as a single elongate body in the northeastern part of the area. In outcrop the rock is a gray weathering, moderately foliated, equigranular rock of medium grain size. Neither gneissic nor relict igneous textures have been seen. In thin section the rock is composed of clinopyroxene and hypersthene intergrown with interstitial quartz and antiperthitic plagioclase. The unit appears to be of plutonic origin; however, its relationship to other intrusive rocks in the area is not clear.

Unit 6 - Foliated quartz diorite-
monzodiorite

This unit forms a single intrusive body located along the Atikonak River. The unit is typically medium grained and has a brown or gray hue due to feldspar coloration, and locally contains microcline megacrysts. Plagioclase and orthoclase feldspar occur intergrown with interstitial quartz and felted aggregates of biotite, opaque and garnet. These aggregates can locally be seen to be replacing orthopyroxene and the unit may be genetically related to Unit 5. Shearing along the Atikonak River has locally converted the rock to augen schist.

Approximately 2 km south of the map area rocks similar to Unit 6 contain numerous xenoliths of sillimanite gneiss, indicating an intrusive relationship with Unit 1. This is consistent with the lack of high grade metamorphic fabrics in Unit 6.

Unit 7 - Pink foliated granite

An outcrop area east of the north end of Panchia Lake consists of pink, fine grained leucocratic granite. The major part of these outcrops are only moderately foliated; locally, however, the foliation takes on a convoluted gneissic character associated with thin

pegmatitic leucosome veins. A third outcrop east of the south end of Panchia Lake consists of pink gneissic granite which may be a more strongly metamorphosed variety of the above rock types.

The moderately foliated granites appear structurally younger than the Unit 1-3 gneisses. The local appearance of gneissic texture suggests that they may be anatectic granites produced from these gneisses.

STRUCTURAL HISTORY

The gneisses of Units 1-3 are characterized by regional north-south structural trends, also apparent on the aeromagnetic map of the area (Geological Survey of Canada, 1974). In outcrop, this structural trend can usually be seen to be a vertical composite fabric which has been produced by tight to isoclinal folding of gneissic banding. Ductile shearing associated with this folding has locally imparted a flaggy, schistose texture to the gneisses, a feature which is particularly apparent along the Atikonak River.

The style of migmatization seen in the Unit 1 gneisses is very similar to that described from Area A, with migmatite veins occurring parallel to F_2 fold axial planes and the composite fabric. This is also similar to the structural style seen in the Unit 1 and 2 gneisses, and there is, as yet, no reason to suppose that all gneiss units were not formed in the same event. The Shabogamo Intrusive Suite also appears to have undergone the same deformational and structural history, although this is by no means confirmed. The *circa* 1400 Ma age for this suite (Brooks *et al.*, 1981) implies a Grenvillian age for the metamorphism and deformation of Units 1-4 (and possibly Unit 5). This conflicts, however, with the pre-1650 Ma age established for the metasedimentary gneisses (Disappointment Lake Gneiss) similar to Unit 1 in the Red Wine Mountains area (Thomas *et al.*, 1981).

The most obvious explanation for this discrepancy is that the pre-Grenvillian event of the Red Wine Mountains area dies out to the west and was not recorded in the Churchill Falls Region. It is also conceivable that Grenvillian orogenesis has been more intense in this region and that earlier fabrics have simply been obliterated. At present, the former hypothesis seems more logical since the southerly extrapolation of the 'Hudsonian Front' of the Churchill Province lies between the Churchill Falls and Red Wine Mountains regions. In this case, Hudsonian metamorphism would be expected to increase in intensity from west to east.

Intrusion of Unit 6 apparently occurred after metamorphism of Unit 1, but prior to shearing along the Atikonak River. Unit 6 would therefore appear to be a late Grenvillian intrusion. Unit 7 may have been produced by anatexis during the climatic stage of Grenvillian metamorphism.

METAMORPHISM

Metamorphic conditions during formation of the Unit 1 gneisses varied from middle amphibolite facies conditions in the north of the area, to upper amphibolite facies south of the sillimanite isograds. The presence of textures indicative of partial melting in the kyanite gneisses suggest that this occurred at pressures of over 6 kb (*i.e.*, over 22 km depth) and at temperatures of over 650°C (Winkler, 1974).

Gneisses of Units 2 and 3 lack metamorphic index minerals, but on the basis of structural similarity to Unit 1, they were probably metamorphosed under the same conditions.

The corona textures seen in the anorthositic gabbros of Unit 4 are probably premetamorphic and related to subsolidus reaction of plagioclase with pyroxene or olivine during cooling at pressures of over 6 kb (Griffin and

Heir, 1974). The corona assemblages were later converted to hornblende-garnet-sodic plagioclase amphibolite facies assemblages during regional metamorphism.

Unit 5, although strongly recrystallized, appears to preserve original igneous mineralogy, including orthopyroxene. Unit 6 appears to have been metamorphosed at lower amphibolite or possibly greenschist facies conditions during late shearing.

THE ORIGIN OF THE OSSOKMANUAN LAKE - ATIKONAK RIVER LINEAMENT

From the preceding description, it is evident that the metasedimentary gneisses of Unit 1 are similar in both lithology and structural style either side of this lineament. It follows, therefore, that this is not a particularly profound structure. The strong aeromagnetic contrast across the lineament is probably in part a function of differential exposure: the gneisses west of the lineament are well exposed and have high magnetic relief, whereas the ground to the east is deeply buried under glacial drift and has low magnetic relief. The contrast may also be enhanced by the appreciably higher magnetite content of the metasedimentary gneisses, in comparison with that of the granitoid gneisses east of the lineament.

Previous mapping to the west of the area, along Ossokmanuan Lake (Rivers, 1981), has indicated the existence of a major thrust, or high angle reverse fault, along the lake. This fault has juxtaposed kyanite bearing gneisses, similar to those of Unit 1, against greenschist grade metasediments of the Labrador Trough. The fault is believed to extend east into the map area and to separate the sillimanite gneisses south of Ossokmanuan Lake from gabbro to the north. The fault also probably accounts for the deflection of gneissic and aeromagnetic trends into east-west orientations south of the lake. East of Ossokmanuan Lake the fault is inferred

to swing south through Panchia Lake and Atikonak River where it becomes a ductile shear zone.

A provisional tectonic model for the area is proposed in which the area is divided into two thrust blocks separated by the Ossokmanuan Lake thrust and Atikonak River shear. The northern block was translated north along a series of ductile shear zones described from the Churchill Falls area to the north (Wardle and Britton, 1981). The southwestern block is only the eastern portion of a much larger lobate thrust block that is inferred to have

overridden the northern block. Movement was accommodated by overthrusting along the Ossokmanuan fault and by a combination of lateral and vertical motion along the Panchia Lake - Atikonak River shear.

Thrusting clearly occurred late in the structural history of the area, following formation of the gneissic fabrics. It is possible that the predominant north-south trend of gneissic fabrics in both thrust blocks is due to lateral east-west directed constrictive stresses set up during northward movement of the thrust blocks.

AREA C - SANDGIRT - LOBSTICK - HOOK BAY
AREA (23H/14E, H/15, H/16)

This area lies at the junction of the Churchill and Grenville structural provinces. The northern limit of Grenvillian deformation trends east-west across the northern part of the area (Figure 4).

The oldest rocks present are various granitic and minor metasedimentary gneisses of the Churchill Province which extend into the area from the north and northwest. These have been intruded by a variety of gabbroid and granitoid plutons ranging in age from very late Aphebian to early Paleohelikian. These are locally overlain with probable unconformity by Neohelikian red beds and conglomerates.

The area is particularly significant because it lies at the junction of two extensive batholith belts (Figure 5). One of these lies along the axis of the Churchill Province (Taylor, 1979), the other along the northern margin of the Grenville Province (Nunn, 1981; Thomas *et al.*, 1981; Ryan *et al.*, 1981).

ARCHEAN - APHEBIAN

Unit 1a - Tonalitic-granitic gneisses

Scattered outcrops of this heterogeneous unit occur throughout the central part of the area. In general, the rocks are white to gray weathering migmatitic gneisses of tonalitic to granodioritic composition, associated with strongly foliated to gneissic tonalites and granites. Many of the outcrops demonstrate complex structural histories in which migmatite gneiss has been intruded by several generations of pre-tectonic leucotonalite, granite and pegmatite dikes. Many of the gneisses also contain amphibolite pods and layers, which may occasionally be recognized as pre-tectonic dike remnants.

The more complex migmatitic gneisses bear general resemblance to gneisses of the Eastern Basement Complex (Wardle, 1979a), which form basement to the Labrador Trough. These are gneisses of Archean age structurally reworked during the Hudsonian Orogeny. The foliated granitoid material in Unit 1a could be either late Archean or Aphebian in age.

Unit 1b - Metasedimentary, metavolcanic gneisses

Interspersed with the granitoid gneisses are several outcrops of probable supracrustal gneiss. The only outcrop of undoubted metasedimentary origin is located in the Churchill River (H15) and consists of well banded biotite gneiss with a 1 m thick band of orthoquartzite. Other outcrops located near the western edge of H16 consist of finely banded felsic and mafic gneisses of possible metavolcanic origin. The age of these rocks could be either Archean or Aphebian.

Unit 1c - Metagabbro, amphibolite, amphibolite gneiss

These lithologies are found interspersed with and intrusive into outcrops of the granitoid gneisses. Rock types encountered vary from metagabbro with relict igneous texture and layering, to hornblende amphibolite and amphibolite gneiss. All types are usually intruded by pegmatite and foliated granite. Amphibolite gneisses are commonly migmatitic. This unit probably includes a variety of protolith ages. Metagabbros exposed on an island in Sandgirt Lake intrude the meta-arkoses of Unit 1e and are clearly of Aphebian age. As such they probably represent a southern extension of the Montagnais Group gabbro sills of the Labrador Trough (Wardle, 1979a). Similar metagabbros elsewhere in the map area may be of the same age. The amphibolites and amphibolite gneisses may be more

highly metamorphosed varieties of these rocks or alternatively could be derived from Archean intrusives.

Unit 1d - Ultramafic

One occurrence of deformed ultramafic, probably pyroxenite was found in H16. Peridotite is also locally seen as cumulate bands in metagabbros of Unit 1c.

Unit 1e - Meta-arkose and minor biotite gneiss

This unit is restricted to an island in Sandgirt Lake where it consists of pink, recrystallized meta-arkoses with sparse interbands of quartz pebble conglomerate. Bedding and crossbedding are well preserved, albeit in a highly oppressed state. With the exception of these features, metamorphic recrystallization has destroyed all sedimentary textures and imparted a granitic appearance to the rock. Bedding is tightly folded with a strong axial planar muscovite foliation. Small patches of granitic mobilizate apparently indicate incipient partial melting.

Along the south shore of the island the meta-arkoses grade locally into banded biotite gneisses, probably developed from pelitic intervals within the arkose sequence.

The meta-arkoses are correlated with the Aphebian Seward Formation arkoses and granule conglomerates of the Labrador Trough, which occur 25 km northwest of the map area. The unit is intruded by folded metagabbro sills and dikes of Unit 1c which, as noted previously, are believed to correlate with the Montagnais Group sills of the Labrador Trough.

LATE APHEBIAN - PALEOHELIKIAN. THE GRANITOID SUITE

Unit 2 - Megacrystic granite

This unit is sparsely exposed around the south shore of Sandgirt Lake, and on the east side of Lobstick Lake. A megacrystic granite located on the southern margin of H15 is also provisionally included in Unit 2.

In outcrop, the unit is a gray weathering, coarse grained, megacrystic rock generally of granite composition. Variation in the K-feldspar megacryst content produces local compositional changes to quartz monzonite and granodiorite. Where deformed the unit becomes reddened and may be difficult to distinguish from Unit 4. The megacrysts, which vary in size from 2 to 4 cm, are generally orthoclase and are set in a coarse groundmass of plagioclase and interstitial quartz. Mafic mineralogy within the map area consists of biotite, with or without hornblende, intergrown with epidote and secondary chlorite. North of the area the unit contains primary orthopyroxene partly altered to amphibole.

The unit also characteristically contains numerous xenoliths of various types of diabase, gabbro and amphibolite. Some of the xenoliths are entrained and may be the boudinaged remains of synplutonic dikes.

Around the south shore of Lobstick Lake, the granite contains small diffuse screens of Unit 1 granitoid gneiss. The granite must intrude these rocks but contacts are blurred by the metasomatic overgrowth of K-feldspar megacrysts in the gneisses. All variations may be recognized between granite gneiss and a megacrystic 'granite' with a gneissic

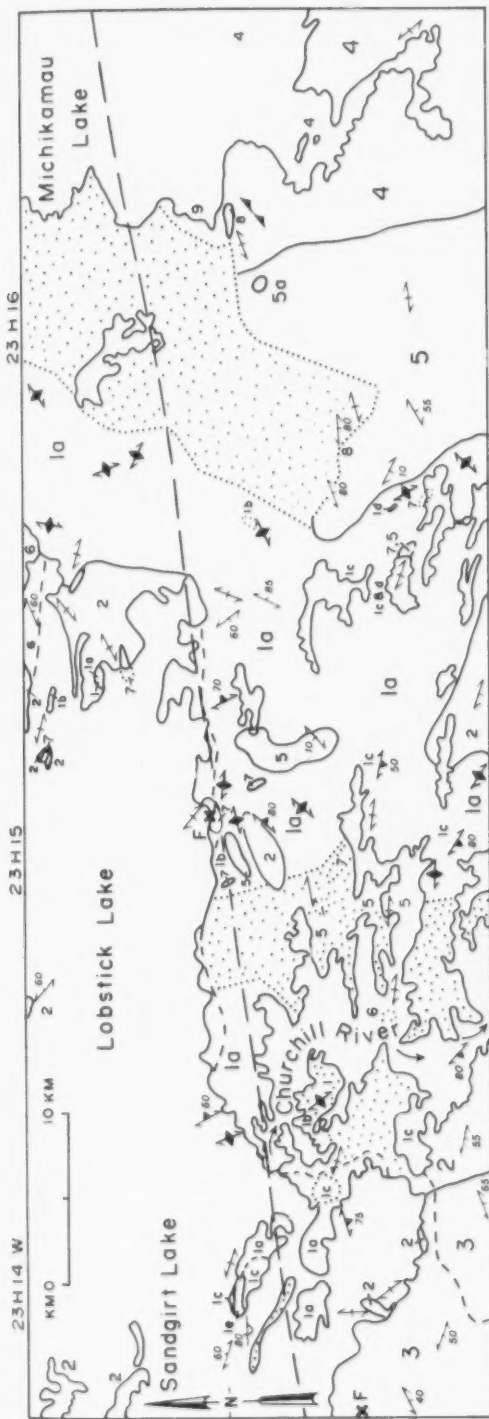


Fig. 4

C

- | | | | |
|--|--|------------------------------------|---|
| 3 | Pink, plagioclase porphyritic monzonite and microgranite | 9 | Pink sandstone and siltstone |
| 2 | Gray megacrystic granite
2a - pink granite | 8 | Polymictic conglomerate |
| ARCHEAN-APHEBIAN | | | |
| 1 | 1a - Tonalitic-granitic gneisses, foliated granitoid | PALEOHELIKIAN-LATE APHEBIAN | |
| | 1b - Metasedimentary, meta-volcanic gneiss | 7 | Diabase-gabbro-diorite, commonly net veined and amphibolitized |
| | 1c - Metagabbro, amphibolite, amphibolite gneiss | 6 | Fine grained gray granodiorite-tonalite |
| | 1d - Ultramafic | 5 | Pink, equigranular granite, quartz monzonite, microgranite; 5a, felsite |
| | 1e - Meta-arkose and minor biotite gneiss | 4 | Pink megacrystic quartz monzonite |
| | | F | Fluorite occurrence |
| <p>--- Northern limit of Grenvillian deformation</p> | | | |

matrix. Similar metasomatic effects have been observed west of the map area along the Atikonak River (Wardle, 1979b). Alignment and augening of the megacrysts in contact regions indicates synkinematic intrusion of Unit 2.

Intrusive into the megacrystic granite are late phases of pink, medium grained, granite and associated aplite (2a). These have also locally been intruded by synplutonic mafic dikes.

The granodiorite and associated granites form the southern tip of an extensive batholith extending along the axis of the Churchill Province. On the geological map of Labrador (Greene, 1970), this is shown as a Paleohelikian body belonging to the Elsonian adamellite suite (*circa* 1460 Ma). However, K-Ar dates by Taylor (1979) indicate a late Hudsonian age of *circa* 1620 Ma. This is supported by the presence of biotite and megacryst alignment fabrics indicative of syntectonic emplacement.

Unit 3 - Porphyritic quartz monzonite and microgranite

This unit is confined to the southwest corner of the map area where it comprises a distinctive pink weathering, plagioclase phyric, quartz monzonite. Plagioclase phenocrysts vary from 0.5 - 2 cm and are usually saussuritized to a pale green colour. The phenocrysts are set in a groundmass of K-feldspar, minor quartz and biotite. Associated with the unit are areas of pink microgranite, probably forming late intrusive phases.

Rb-Sr whole rock dating of the unit has been attempted and yielded a very poorly defined errorchron of *circa* 1700 Ma (C. Brooks, personal communication).

Unit 4 - Megacrystic quartz monzonite

This unit is found south of Lake Michikamau in H16 and forms part of a large pluton centered on the area east

of the lake (see Nunn and Noel, this volume). The unit is also equivalent to Unit 2a of Area A. The quartz monzonite, varying locally to quartz syenite and granite, is generally pink weathering and megacrystic with 1-3 cm diameter K-feldspars. The megacrysts are set in a coarse grained matrix of plagioclase, interstitial quartz, biotite and hornblende. Sphene, magnetite, apatite and epidote form common accessory phases, usually intergrown with biotite or hornblende. The unit is distinguished from the similar lithology of Unit 2 by its pink colouration, smaller megacryst size, and paucity of mafic inclusions.

Preliminary Rb-Sr dating of this unit in the east Lake Michikamau area (Nunn and Noel, this report) has yielded an errorchron age of 1715 ± 100 Ma (Brooks, personal communication). As noted previously, this age conflicts with a 1525 determination on volcanics intruded by the pluton (see Nunn and Noel, this volume).

Unit 5 - Granite-microgranite-quartz monzonite

This heterogeneous unit occurs as a belt adjacent to Unit 4, where it is contiguous with Unit 2b of Area A; and as an isolated sequence of outcrops south of Lobstick Lake. Typical lithologies are pink, fine to medium grained granites, microgranites and aplites with minor amounts of quartz monzonite. Textures are usually equigranular but may locally be porphyritic, or even megacrystic, with K-feldspar.

One example of felsite (5c), probably a hypabyssal intrusion, was noted approximately 5 km west of Hook Bay.

Unit 6 - Granodiorite and tonalite

These are chiefly exposed along the north shore of Lobstick Lake. An isolated foliated tonalite also occurs in the Churchill River on H15. The rocks

are typically gray weathering, fine grained granodiorites, containing hornblende and poikilitic biotite. Inclusions of amphibolite and cognate xenoliths of granodiorite are also found. Medium grained hornblende-biotite tonalite exhibiting a weak, northeast trending primary fabric forms two minor components of this unit in north Lobstick Lake. The age of these rocks relative to other granitoid units is unknown.

Unit 7 - Diabase, gabbro, diorite

These rocks occur as small bodies in close spatial association with the granitoid lithologies. The predominant rock type is a pale to medium gray, biotite gabbro (or diorite) varying in texture from coarse diabase to medium grained gabbro. The rock is generally fresh or weakly foliated and contains stubby plagioclase laths enclosing clinopyroxene which is partially or almost completely altered to amphibole (hornblende?). Dark reddish biotite forms distinctive poikilitic plates 1-2 mm long. Quartz occurs as a minor interstitial phase. The pyroxene-amphibole reaction appears magmatic rather than metamorphic and indicates a dioritic affinity for the unit. The gabbroids intrude the megacrystic granite of Unit 2 post- tectonically (*i.e.*, post-primary fabric). In other units, however, the gabbro-diorites are usually net-veined by aplite and pegmatite, and are locally amphibolitized and partially assimilated by their hosts. They appear, therefore, to have been intruded synplutonically with the major part of the granitoid suite.

In the southern part of the area where all rock types have been strongly deformed and metamorphosed, this unit is difficult to distinguish from some of the metagabbros of Unit 1c, particularly in small, poorly exposed outcrops. It is possible, therefore, that some of the Unit 1c lithologies belong to Unit 7 and vice versa.

NEOHELIKIAN

Unit 8

Polymictic conglomerate is exposed at two localities; in the central part of H16, and near the west shore of Lake Michikamau. The conglomerates are generally massive and strongly cleaved. Clasts, usually of pebble size, but ranging up to boulder size, are well rounded and set in an epidotized, gray sandstone matrix. The clasts are composed largely of aplite, epidotized gray felsic porphyry, pink felsic porphyry and microgranite, with lesser amounts of vein quartz and altered basalt. Rare clasts of red, feldsparphyric rhyolite and foliated tonalite have also been noted. The microgranites, aplites and porphyries are lithologically similar and appear to have been derived from a hypabyssal volcano-plutonic source. No units of this nature, with the possible exception of the Unit 5a felsite, have been observed in the area, and it appears that the source must have been higher levels of the granitoid suite, now removed by erosion.

Identical rocks have been mapped by Nunn (1981) in the east Lake Michikamau area where they are interbedded with pink sandstones equivalent to Unit 9 of this report (see below). Both lithologies are interpreted to unconformably overlie quartz monzonite equivalent to Unit 4 of this report, and to be of Neohelikian age. Nunn (1981) has further suggested a correlation with the Seal Lake Group exposed east of Lake Michikamau.

Unit 9 - Pink sandstone and siltstone

This unit is poorly exposed on the west shoreline of Lake Michikamau, where it consists of maroon to pale pink and yellow, finely crossbedded sandstone. Bedding attitudes are shallow and a moderate vertical cleavage is present. The belt of sandstones extends under the lake and is exposed on islands immediately east of the map area (Nunn,

1981) where the sandstones are interbedded with thin, red siltstone horizons. The unit may also have a considerable extent under the broad expanse of drift west of Lake Michikamau.

Late Dikes

Several fresh basalt dikes have been observed to intrude Units 1e and 7. Their trends are variable and their age is unknown.

STRUCTURE AND METAMORPHISM

The gneisses, amphibolites and metasediments of Unit 1 have been strongly deformed and metamorphosed in the Hudsonian Orogeny. Structures developed during this event are subvertical with north-south or northeast-southwest trends in the eastern part of the area, and northwest-southeast trends in the west. Folds in Unit 1e are reclined to the southwest.

Unit 2 of the granitoid suite appears to have been intruded during the late stages of the Hudsonian Orogeny. Some of the primary fabric development in Units 4 and 6 (see also Nunn and Noel, this volume) may also be related to late stage, syntectonic emplacement.

The granitoid suite is inferred to have been uplifted and deeply eroded sometime towards the end of the Paleohelikian, an event that elsewhere in Labrador coincided approximately with the close of the Elsonian intrusive event of *circa* 1450 Ma. This event does not appear to have been associated with any penetrative deformation.

Rocks in the area south of Lobstick and Sandgirt Lakes were variably deformed during the Grenvillian Orogeny *circa* 1000 Ma. The approximate northern limit of Grenvillian foliation and cleavage is shown in Figure 4. The only effects of deformation north of this line are isolated narrow shear zones.

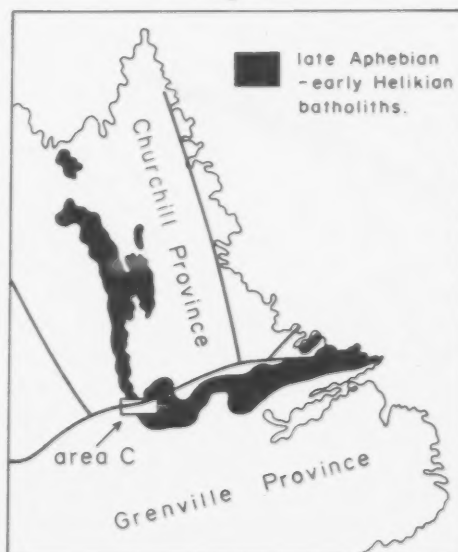
Grenvillian structures consist of cataclastic or low grade penetrative foliations of undulatory east-west trend and steep southerly dip. Fabric trends in the gneisses are irregular, a feature which is probably due to partial reorientation of earlier structures.

Metamorphism associated with the Grenvillian deformation produced largely greenschist facies assemblages. North of the deformation limit, the metamorphism is seen as a static retrogression. South of the limit it is associated with both penetrative and cataclastic fabric development and increases from chlorite grade (chlorite-actinolite-epidote-albite assemblages) to biotite grade near the southern boundary of the map area.

DISCUSSION

As shown in Figure 5, the area lies at the junction of two batholith belts. The megacrystic granites of Unit 2 form the southern margin of the Churchill Province batholith. These rocks were apparently emplaced at fairly deep crustal levels during the waning stages of the Hudsonian Orogeny. The other granitoid units of the area represent

Fig 5



the western extremity of the northern Grenville Province batholith. These rocks generally lack the primary fabrics seen in Unit 2 and may have been emplaced immediately after the Hudsonian Orogeny in the period 1700-1600 Ma. Age dating is still in progress on many of these units. It is apparent, however, that many of the plutonic rocks in the area, previously regarded as Elsonian (in particular Unit 4; Greene, 1970, 1974) are probably early Paleohelikian or late Aphebian.

The significance of the two batholiths is not completely understood. They represent syn to post-Hudsonian batholiths and could be either the root zones of volcanic arcs or be related to crustal suturing and accretion during the terminal stages of the Hudsonian Orogeny.

MINERALIZATION

No significant mineralization has been previously recorded from the area. The only mineralization encountered during this work were minor fluorite showings in the quartz monzonites of Unit 3 and in granite intermixed with gabbro-diorite of Unit 7. However, the abundance of granitoid rocks in the area has not previously been recognized and it is possible that some of these may be worth further investigation.

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REGIONAL GEOLOGY EAST OF MICHIKAMAU LAKE, CENTRAL LABRADOR

by

G.A.G. Nunn and N. Noel

INTRODUCTION

NTS map areas 13L/3, 4, 5 and 6 and the shore of Windbound Lake in map area 13E/14 were mapped during the summer of 1981. Together with 13E/13 and the remainder of 13E/14, these areas complete the regional mapping program to the east of Michikamau Lake. In addition, reconnaissance visits were made to areas of known sedimentary lithology up to 30 km west of Michikamau Lake.

In 1972, parts of the area were flooded to form part of the Smallwood Reservoir. The map has been corrected to show the approximate extent of this flooding. The flooding provides continuous lakeshore access throughout the south and central parts of the map area. The eastern portion of the map area is mostly accessible from a tote road which winds northeastwards from Churchill Falls as far as Sail Lake. More remote areas in the west, north and east are accessible only by helicopter.

The area is an undulating plateau varying from approximately 540 m in the north to 500 m in the south (now flooded). This plateau is covered by glaciofluvial outwash northwest of Sail Lake and by a blanket of moraine over most of the remaining area. Residual hills and massifs of higher erosion levels occur in areas underlain by intrusive lithologies. Abundant outcrop occurs in the belt of hornfels (1) and adjacent anorthositic rocks (5), and as lakeshore exposures of the eastern supracrustal belt (1) and some of the granitoid rocks (4). The volcanics (3a) and isolated areas of Units 2, 4a and 4c to the east of Sail Lake are also well exposed in isolated moraine stripped patches. Unit 6 is well exposed in river gorges.

Mapping was undertaken using 1:50,000 or 1:250,000 topographic base maps together with aerial photographs at a variety of scales from 1:80,000 to 1:40,000 for compilation at 1:100,000. The bulk of the area was covered by helicopter reconnaissance, supplemented by lakeshore boat traversing, and ground traversing using helicopter or road access.

PREVIOUS WORK

Reconnaissance visits to southern portions of the area were made by Low (1895, 1897) and Thompson (1949, 1953). The Michikamau Intrusion (5) has been mapped and described in detail by Emslie (1964b, 1965, 1969, 1970) and little further work on the intrusion was undertaken during this mapping program. Emslie's work also included studies of the metasedimentary lithologies (1970, 1978 and Emslie in Wanless and Loveridge, 1978, pages 45-46).

The area is also covered by the Geological Survey of Canada 1:250,000 map of Emslie (1964a) and the 1:1,000,000 provincial compilation of Labrador by Greene (1972).

The previous work in the area indicated that a metamorphic complex (the Churchill Province gneisses) and a supracrustal sequence (the Petscapiskau Group, Emslie, 1970) were intruded, firstly, by the Michikamau anorthositic Intrusion (Emslie, 1965) and, subsequently, by a granitoid suite that is temporally and spatially related to the anorthositic rocks (Emslie, 1978). Both intrusive units have been placed in the Elsonian plutonic event (Emslie, 1964b, 1978). Red beds of the Neohelikian Seal Lake Group, which is unconformable upon Elsonian plutons to the east of the map area (Brummer and

Mann, 1961; Greene, 1974; Marten and Smyth, 1975), occur in the northeast of the map area. In their southern part, the red beds were folded during the Grenvillian Orogeny. Other red beds in adjacent areas, some of which are flat lying and undeformed, have been variously assigned: (i) a Helikian age, and tentatively correlated with the Seal Lake Group (Emslie, 1970), (ii) a Hadrynian age (Low, 1897) or (iii) either (Greene, 1972).

Considerable uncertainty is present in the literature concerning the age and extent of the Petscapiskau Group. The Petscapiskau Group was named after Petscapiskau Hill in map area 23I/8 (Emslie, 1970). The name was applied to the belts of supracrustal hornfelses bordering the southeastern and western margins of the Michikamau Intrusion and described as including paragneiss, schist, quartzite, metatuff and amphibolite and their contact metamorphosed equivalents. Emslie has proposed both Aphebian (1964a, 1965) and Paleohelikian (1978, in Wanless and Loveridge, pages 45-46) ages for the group. Greene (1972, 1974) indicated an Aphebian or Paleohelikian age and most recently Emslie (1978) proposed that the group is composite with lower Aphebian and upper Paleohelikian components. A recalculated Rb-Sr whole rock isochron of 1558 ± 60 Ma has been obtained for the volcanic portion of the upper Petscapiskau Group (given by Emslie, 1978, from an initial age of 1473 ± 60 Ma in Wanless and Loveridge, 1978).

Work in the adjacent map area (Nunn, 1981a) showed that: (i) supracrustal rocks in 13L/3 that have been correlated with the Petscapiskau Group are Aphebian and are the oldest rocks in the area; (ii) the quartzofeldspathic orthogneisses of the Churchill Province in this area were emplaced into the supracrustal rocks before and during the Hudsonian Orogeny; (iii) isolated patches of sedimentary rock in the north of 13E/14 appeared to be Paleohelikian or younger; (iv)

Neohelikian red beds occur in the Windbound and Michikamau Lake basins and are probably correlative with the Seal Lake Group.

With the above points in mind, this season's objectives were to continue studies of the supracrustal sequences in the area in order to elucidate their stratigraphy, structure and mineral potential; and in particular to:

- (i) look at the type sections of the Petscapiskau Group in an effort to establish its structural and chronological relationships to these sequences;
- (ii) look for mineralization in the Seal Lake Group (Cu- and U-bearing to the west of the map area, Brummer and Mann, 1961; Gandhi and Williams, 1970; Marten and Smyth, 1975);
- (iii) look for basement cover relationships within the Churchill Province gneisses and/or in relation to the Petscapiskau Group;
- (iv) determine the northern limit of Grenvillian deformation in the area and also to determine the age of early north-northeast trending fabrics found in the granitoid rocks.

GENERAL GEOLOGY

APHEBIAN

Unit 1 - Petscapiskau Group

The term Petscapiskau Group, as defined in this report, is restricted to pre-Hudsonian supracrustal rocks. Various post-Hudsonian red beds and volcanics included in the group by Emslie (1978) have been assigned to Unit 3 of this report. The Petscapiskau Group

embraces a variety of Aphebian, greenschist to amphibolite facies supracrustal rocks along with some equivalent hornfels. These include a range of mafic to felsic volcanics with associated intrusive, fragmental and sedimentary rocks. The metasedimentary rocks include quartzite, metagraywacke, psammitic to pelitic schists and gneisses.

The Petscapiskau Group outcrops as two discontinuous curvilinear belts. The first, oriented north-south, extends along the eastern portion of the map area whereas the second belt which trends north-northeast - south-southwest is found in the western part of the area. The outcrop pattern is controlled mainly by the later intrusions of Units 2, 4 and 5 but is, in part, of tectonic origin.

The following description of the Petscapiskau Group is divided into lithological subunits. These are generally too limited in extent to show on the accompanying map, but will be delineated in future map publications.

Mafic volcanic rocks

Mafic volcanic rocks are the most abundant components of Unit 1. These outcrop throughout the eastern belt and in the southernmost part of the western belt and consist mostly of olive green to dark gray weathering, fine to medium grained amphibolite. Locally, they exhibit pillow structures (up to 2 m across); however, severe deformation during the Hudsonian Orogeny has obliterated most primary features. Recognition of these rocks is therefore based on a combination of textural, mineralogical and primary structural features as well as field relations.

The volcanic rocks commonly contain interbeds of thin (1-2 m), fine grained, green to gray weathering, banded amphibolite, many of which appear to be metatuffaceous rocks and may include crystal-lithic tuff horizons. However,

in some cases where pillow lavas are strongly deformed, the metatuffaceous amphibolites may be confused with layers of highly flattened pillow material. Locally, zones of pillow lava contain layers of amphibolite with an abundance of angular blocks or fragments which are interpreted as pillow breccias.

Pillow interstices usually consist of saussuritized feldspathic material; however, both calcite and quartz have also been found northwest of Mackenzie Lake.

Thicker (greater than 10 m) layers of tuffaceous rocks are present in addition to the thin horizons noted above. These are lithologically similar to the smaller layers and are commonly interbedded with intermediate crystal-lithic tuffaceous rocks. Where thinly laminated, it is difficult to distinguish between these rocks and volcanogenic sediments.

Elsewhere thin discontinuous mafic layers, presumably of tuffaceous origin, are found within the metasediments and pelitic to psammitic higher grade equivalents.

Leucocratic volcanic rocks

In parts of both the northern and southern areas of Unit 1 in map area 13L/3, a few thin bands of light green to gray pillow lava outcrop. The pillows in these bands are small (15 x 10 cm) and strongly deformed. The pillows are composed mostly of light green minerals which are probably saussuritized plagioclase; they lack obvious mafic phases. Probable pillow breccias of the same composition are also abundant in these localities and they are interlayered with light coloured crystal-lithic tuffaceous rocks containing abundant plagioclase phenocrysts. The leucocratic rocks may represent a more intermediate phase of volcanism, possibly of andesitic composition.

LEGEND

NEOHELIKIAN

- 6 Seal Lake Group and equivalents: Red beds; arkosic and subarkosic arenites; siltstone; granule to boulder conglomerate and breccia; minor fine grained metabasic flows.

PALEOHELIKIAN

- 5 Michikamau anorthositic Intrusion.
- 4 Michikamau plutonic suite*: 4a, Gabbro, metagabbro and amphibolite; 4b, quartz diorite and quartz monzodiorite; 4c, undifferentiated, predominantly K-feldspar megacrystic quartz monzonite, quartz syenite and granite; 4d, granite.
- 3 3a, Acid to basic volcanics, predominantly andesitic; 3b, arkosic red beds; thinly bedded siltstone; tuffaceous grit, sandstone and siltstone; eolian sandstone; tuff; sedimentary and granitoid hornfels.

APHEBIAN

- 2 Churchill Province gneisses: Predominantly foliated tonalitic and granodioritic plutonic rocks and well to diffusely layered, veined and granite sheeted, gneissic equivalents; foliated and veined granitic rocks; fine grained porphyroclastic granitoid rocks; contact metamorphic pyroxene granulite. Contains disrupted mafic dykes and inclusions of paragneiss and amphibolite (Unit 1).
- 1 Petscapiskau Group and equivalents: Mafic and felsic pillow lava, tuff and volcanoclastic sediment with gabbro intrusions; pelitic to psammitic schists and their contact metamorphosed equivalents; quartzite; quartz-pebble and rhyolite-porphyry boulder conglomerate.

NOTES:

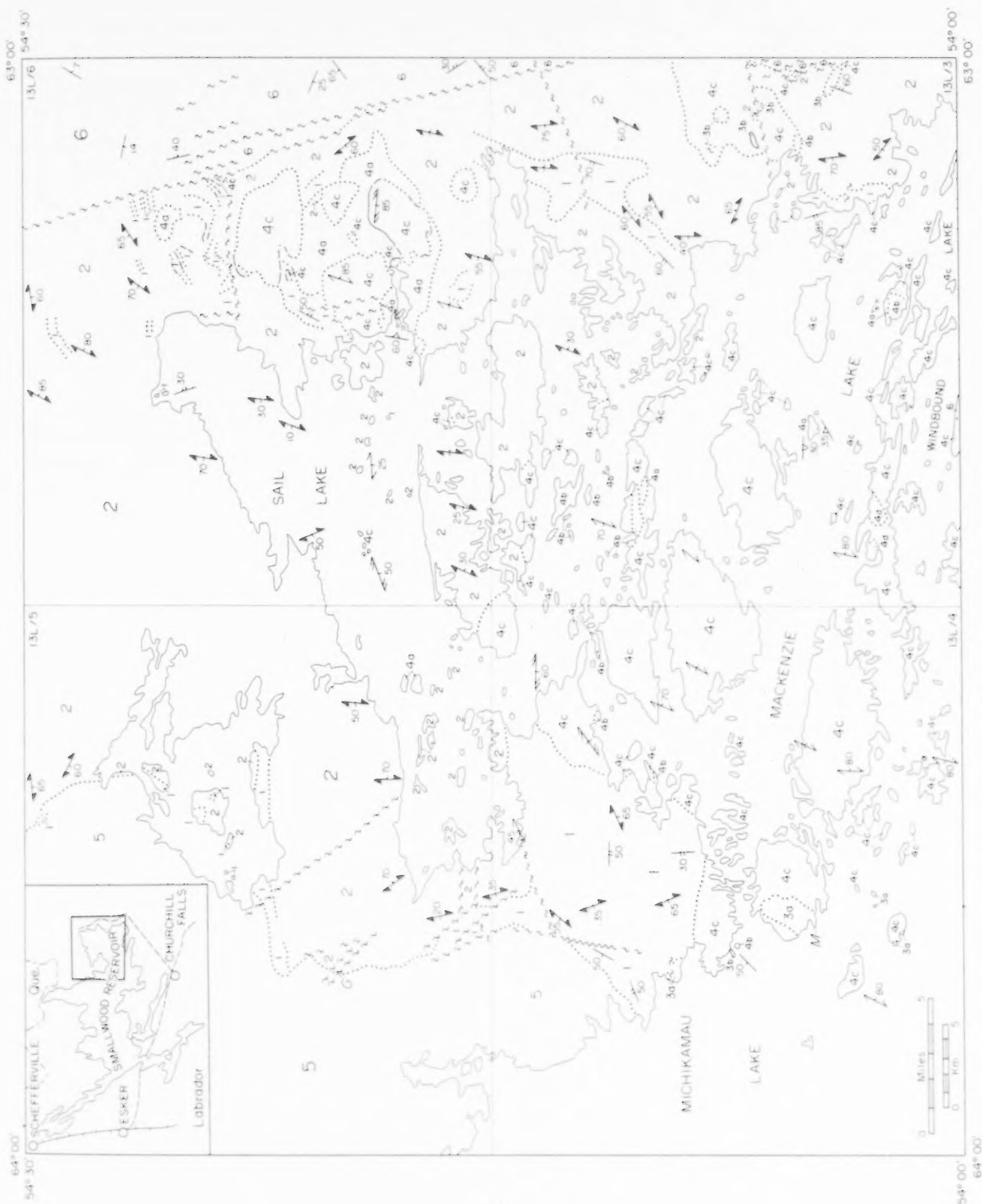
Unit subdivisions are not necessarily in chronological order.

*Granitoid terminology, adapted from IUGS guidelines using mineral proportions of quartz, plagioclase and K-feldspar, is based on field observations.

Provisional base map compiled from 1:50,000 air photo mosaic. Lakeshore outline preliminary and most small islands omitted.

SYMBOLS

Foliation and Gneissosity (Hudsonian)	↖
Foliation (Paleohelikian or younger)	↗
Gossan	G
Megacrystic dike	M



Regional geology east of Michikamau Lake, Central Labrador

Volcaniclastic siltstone and sandstone

Unit 1 locally consists of a gray weathering, rusty, thinly bedded siltstone-sandstone sequence which occurs in both the eastern and western belts of Unit 1 and is interbedded with the volcanic portion of the unit.

The volcaniclastic sequence is best developed on the two small islands at the northernmost tip of Sail Lake and in the northern portion of the 13L/3 map area. In both of these areas the rocks form a quartzofeldspathic siltstone-sandstone sequence with minor amphibolite and pyritic layers. On the islands in Sail Lake the volcaniclastic sequence is interbedded with mafic volcaniclastic rocks (water-lain tuffs?) and several thin horizons of crystalline tuff. In the northern part of map area 13L/3, one outcrop contains a thick horizon of possible mafic to intermediate agglomerate or redeposited volcanogenic sediment.

Similar occurrences are found throughout 13L/3 and in the area northwest of Mackenzie Lake. At the latter locality, more mafic varieties of siltstone and sandstone occur closely associated with mafic volcanics.

Pelitic to semipelitic paragneiss

Layers of semipelitic to pelitic paragneiss and metasediment are discontinuously exposed throughout the eastern belt of Unit 1.

In the northeast, these outcrop as a well banded, rusty weathering, quartz-feldspar-biotite-almandine gneiss, containing biotite and quartz-rich layers and thin discontinuous bands of amphibolite. Locally, metatexite is developed and is characterized by garnetiferous granitic material of heterogeneous grain size forming layers or zones within the paragneiss and containing small restite schlieren.

In the central portion of the eastern belt, these rocks outcrop as rusty weathering metasediment containing garnet and porphyroblasts of sillimanite in addition to thin quartzite layers and swells. These rocks show evidence of static recrystallization which may be due to the thermal effect of a later, nearby gabbro-granite intrusive complex (Unit 4) situated a few kilometres to the east-southeast. In one location in this area, these rocks can be seen to grade westward into interbedded pelite and mafic metatuffs and then into interbedded tuff and mafic pillow lava.

In the southern portion of the eastern belt, these rocks are mostly semipelitic and commonly contain thin quartzite and tuffaceous bands. Garnet has only rarely been observed in this area.

Quartzite and conglomerate

Two large occurrences of quartzite were mapped and included in Unit 1 near the northern edge of the 13L/3 map area. The quartzite outcrops as a well bedded, mostly white weathering orthoquartzite with minor pyritic and grit bands. The northernmost occurrence of quartzite grades southward along strike into a quartz pebble conglomerate. The quartzite appears to underlie mafic volcanic rocks of Unit 1 but contains no evidence of syndepositional volcanic activity.

In addition to the quartz pebble conglomerate mentioned above, a few local occurrences of conglomerate were found within the eastern belt of Unit 1. One occurrence outcrops as a 3 m wide band overlying mafic pillow lava. Clast lithology is dominated by microgranite with a few minor amphibolite clasts. The matrix is composed mostly of fine grained, quartzofeldspathic (?tuffaceous) sandstone detritus. Minor bands of conglomeratic material also occur within other areas of outcrop of volcaniclastic rock. Clasts range from

1-8 cm long by approximately 1 cm; however, some have been flattened and stretched to such a degree that they have the appearance of discontinuous bands. Some of the conglomerates may be pyroclastic in origin.

Rhyolite porphyry conglomerate

Rhyolite porphyry conglomerate has not been previously reported from this area. It outcrops in the centre of the southern portion of the western belt of Unit 1 and consists of pink to green weathering conglomerate with clasts of pink, quartz and K-feldspar porphyritic rhyolite, microgranite and minor clasts of pink nonporphyritic rhyolite. The matrix appears to be a plagioclase rich sandstone and may be in part tuffaceous. Clasts are well rounded to subrounded and average 10 cm in diameter. Occasionally, clasts of fine grained mafic volcanic material are also found. The conglomerate grades eastwards over a distance of 2-3 km into a mixture of finer grained conglomerate and possible fragmental tuff containing abundant, rhyolitic, shard-like fragments concentrated in discrete horizons.

Five kilometres further east, the conglomerate has been replaced by a quartz-feldspar-muscovite + chlorite-bearing metagraywacke. The graywacke is characterized by abundant, highly deformed, discontinuous quartz veins. A zonation of chlorite, andalusite and possibly cordierite porphyroblasts overprints the cleavage with progressive proximity to the inferred Unit 4 contact.

The relationship of these clastic rocks to the rest of the supracrustal sequence is still unclear; however, facing directions obtained from nearby mafic pillow lavas along with some possible graded bedding in the conglomerates, suggests that it underlies the mafic volcanics found to the west. No comparable rock type was found in the eastern belt of Unit 1.

Subophitic - ophitic metagabbro

Outcrops of metagabbro belonging to Unit 1 are found throughout the eastern belt as part of larger, possibly subvolcanic, intrusions. In the western belt the metagabbro is restricted to thin (1-2 m) dikes. In outcrop the metagabbro is a green to dark gray weathering, fine to coarse grained rock with relict subophitic to ophitic texture. In the more massive outcrops, quartzofeldspathic net veining is common. Contacts between these gabbroic rocks and the rest of the supracrustals are rarely seen.

Plagioclase cumulate metagabbro

This metagabbro is restricted to the central and northern portions of the eastern belt of Unit 1. It consists of large, saussuritized plagioclase crystals (up to 10 cm long) set in a fine grained, amphibolite matrix. Where deformed, this rock may be distinguished by the presence of a light apple green mica, possibly fuchsite, and small plagioclase-rich polycrystalline aggregates which represent relict plagioclase cumulate crystals.

Hornfels

A belt of hornfels occurs adjacent to the Michikamau anorthositic intrusion (5). The aureole is over 3 km wide and reached pyroxene hornfels facies nearest to the anorthositic intrusion. Pyroxene, cordierite, sillimanite and andalusite are the main index minerals. Garnet is not abundant in the hornfels indicating a generally low Fe-Mg ratio in the sediments.

The hornfels are massive and resistant to weathering. They consist of thick homogeneous pelitic members, thinner psammitic members and a facies consisting of interbedded pelitic and psammitic layers. The sequence also contains amphibolite layers. Major bedding variations within the hornfels are still visible. A prominent feature

of the pelitic layers is a pervasive quartz vein segregation which is similar to that found in the regional grade pelites of Unit 1. The segregations have clearly undergone at least two deformations prior to the contact metamorphic overprint. Other structures, such as cleavage, are sometimes mimetically overgrown by aluminosilicate minerals. In general, however, the hornfels is relatively isotropic.

Reconnaissance visits were made to the hornfels underlying Petscapiskau Hill and to other areas of greenschist to amphibolite facies metasedimentary rocks west of Michikamau Lake in map areas 13L/1, 2 and 8 (Emslie, 1963; Greene, 1972). The hornfels is correlated with these and other rocks of similar complexity in the map area (Unit 1).

Unit 2 - Churchill Province gneisses

Unit 2 is a foliated to gneissic suite of granitoid plutonic rocks. The granitoid lithologies range in composition from diorite to granite with tonalites and granodiorites the most abundant. The suite has not been subdivided on the accompanying map but will be in future map publications.

The earliest members of Unit 2 are gray, medium grained, biotite hornblende tonalites and diorites which form less than 5% of the unit. They occur only in the south of map area 13L/3 adjacent to, or enclosing, amphibolites of Unit 1. The early rocks and the amphibolites are intruded by dark gray, fine grained, trondhjemite-banded, biotite tonalite. The biotite tonalite may also occur as screens in younger phases throughout the south and eastern outcrop area of the gneisses and would appear to be a good time marker in the plutonic sequence. The main migmatitic banding in the biotite tonalite is cut by the enclosing lithologies. Some dark to light gray, generally fine grained tonalites and quartz diorites are presumed to be younger than the biotite tonalite because they lack any form of regular

migmatitic banding. They may be homogeneous but are commonly spotted with plagioclase and/or hornblende. They occur as schlieren, inclusions and tabular xenoliths throughout the same area, and enclosed in the same phases, as the biotite tonalite. All these early lithologies are volumetrically insignificant.

By far the most voluminous members of Unit 2 are cream weathering, medium grained, biotite + hornblende tonalite and cream or gray weathering, medium grained, biotite granodiorite. The former occurs most extensively throughout map area 13L/3 and to the northeast of Sail Lake; the latter occurs mostly around Sail Lake itself. Southwest of Sail Lake, adjacent to Unit 1, an adamellite is present due to a greater proportion of microcline. All three phases have been metamorphosed to granoblastic aggregates of quartz, plagioclase and microcline, although the microcline is commonly partially preserved as porphyroclastic relicts. The granoblastic aggregates and an alignment of the ferromagnesian minerals usually define a strong linear fabric throughout the gneisses. Posttectonic static recrystallization increases northwards throughout the map area and has commonly reduced the intensity of the linear fabric.

Both the tonalites and the granodiorites show the same intrusive and structural relationships. They are regarded as compositional variants of a temporally related intrusive stage within Unit 2. All older rocks are diked or enclosed by this period of granitoid emplacement. The two lithologies themselves generally contain a sparse leucocratic layering or granite sheeting. Locally, south and east of Sail Lake, these features intensify into a major gneissic layering. In places the development of the gneissosity is accompanied by partial melting and a biotite-rich paleosome may occur between the felsic layers. The gneissosity predates the rodding.

Three other volumetrically important lithologies in Unit 2 differ markedly from the above tonalites and granodiorites but were probably emplaced more or less contemporaneously with them. The first rock type, occurring east of Sail Lake, is a diffusely granitoid-banded, fine to medium grained, gray weathering, biotite-bearing, quartzofeldspathic gneiss. The gneiss contains inclusions of Unit 1 and older Unit 2 rock types. Though possibly younger than the main tonalite both the quartzofeldspathic gneiss and its layering also predate the foliation.

Northwest of Sail Lake, gray, fine to very fine grained granitoid rocks comprise the second lithology. They contain porphyroclastic relicts of potash feldspar and coarser grained quartzofeldspathic veins that are also strongly porphyroclastic. The regional lineation is well developed in the fine grained rocks and they appear to represent a broad, high strain (possibly mylonitic) zone developed pre- or synkinematically with respect to the main period of deformation.

The third rock type occurs in a belt of hornfels 1-2 km wide adjacent to the anorthositic intrusion (5). Possible predominantly granodioritic and coarse grained adamellite rocks with minor tonalite, have been statically recrystallized during contact metamorphism to biotite + pyroxene + hornblende-bearing granulites.

The last group of intrusive phases in Unit 2 is also less than 5% in volume. Associated with the diffusely-banded gneiss east of Sail Lake is a leucocratic, white weathering, fine to coarse grained, mafic-spotted tonalite which occurs as discordant sheets. The mafic spots consist of greenish, intergranular patches of amphibole and black, posttectonic, porphyroblastic clots of biotite. In the southeastern part of the area, the main tonalites are intruded by two later phases. The first is a gray, white weathering, fine

grained, biotite granodiorite. The second is a cream weathering, medium to coarse grained biotite + hornblende granodiorite. Of these three phases, the first two are pre-foliation but do not display a strong rodding; the last is deformed, but the foliation is zonal and not as strong as that in the main phases. The coarser granodiorite is regarded as syntectonic with respect to the foliation development.

Throughout the intrusive and tectonic history of Unit 2 massive amphibolite and ultramafic members of Unit 1 have been deformed in a more brittle manner than the enclosing granitoid rocks. Fractures in these bodies have been intruded by white weathering, granitic and pegmatitic net-vein systems.

A set of pink, aplitic, microgranite sheets, and granite and pegmatite dikes cut all rock types from Unit 1 to the later Unit 2 granodiorites. The main and late phases of Unit 2 are also cut by a set of cream weathering felsic veins. Both vein sets span the time of the main deformation.

In addition to their main mineralogy, all the members of this plutonic association (Unit 2) contain epidote, magnetite and allanite. Sphene and garnet may also be present.

PALEOHELIKIAN

Unit 3 - Volcanic and red bed sediment sequence

Unit 3 occurs in isolated patches throughout the two southern map areas, chiefly around the western and eastern flanks of the Unit 4 outcrop area. The unit is heterogeneous and comprises red beds and the felsic volcanics assigned by Emslie (1978) to the 'upper Petscapiskau Group'. In the west, the unit is composed predominantly of volcanic rocks (3a) which underlie two prominent hills on the east shore of Michikamau Lake and a group of lakeshore

outcrops further south. Both the hills and the lakeshore outcrops are underlain by roof pendants, up to 3.5 km across, in Unit 4.

The largest outcrop area consists of andesitic volcanics. The andesites contain phenocrysts (50-60%) of plagioclase and ferromagnesian minerals in a fine grained, felsic groundmass. The main variants of this lithology are a densely plagioclase porphyritic facies and a fine grained rock in which the plagioclase and/or ferromagnesian phenocrysts rarely exceed 1 mm across. The plagioclase-rich rock commonly contains a fabric alignment of the feldspar phenocrysts and rarely a weak cleavage anastomoses around them in the groundmass.

Outcrops of acidic volcanic rocks map out as a roughly north-south orientated band within the andesites. They are plagioclase porphyritic (up to about 40%) with a fine grained, usually aphanitic groundmass. Locally the groundmass is streaky or the plagioclase aligned, and zones of the rock also contain quartz eyes up to 8 cm across. The eyes are elliptical and recrystallized and this deformation fabric parallels the streakiness and the aligned plagioclase laths. The quartz eyes, together with the streaky groundmass, suggest that these rocks may be pyroclastic flows. The acidic volcanics are intruded by glassy dikes.

The more northerly of the two prominent hills is also underlain by andesitic rocks. Vug-like patchy development of amphibole + plagioclase + epidote and isolated or clustered hornblende porphyroblastesis have imparted a spotty appearance to some areas of outcrop. Stellate growths of plagioclase and the randomly developed patches suggest that the rock is a hornfels.

Several small islands, south of the main volcanic hill, consist of green weathering, fine grained, dominantly

aphyric rocks of metabasaltic appearance. They may contain tiny plagioclase needles or scattered hornblende phenocrysts up to 3 mm long. The outcrops on the larger islands are andesites.

In all three outcrop areas, the andesitic rocks contain dikes of Unit 4 lithologies. The increased intensity northwards of the irregular spotting in the northern area and the absence of such features in the other areas indicates that the hornfels was produced by the Michikamau anorthositic Intrusion (5) rather than the granitoid plutons of Unit 4. The general absence of cleavage in all the rocks of this unit might be due to contact metamorphism which is manifested only on a microscopic scale.

Two outcrops of sedimentary rock (3b) also occur in the western area. The first is a sequence of siltstone and fine grained sandstone interbedded with grit. The beds are planar topped and bottomed and even the thinnest beds are continuous over the outcrop strike length of about 18 m. The beds seem relatively quartz-poor, feldspar-rich and immature. Magnetite is a major heavy mineral component in the sediments. The sediments are probably of tuffaceous or volcanic derivation. In their fresh state, the rocks are dark gray and recrystallized and appear to be undeformed hornfels.

The second outcrop consists of crossbedded, pink, orange and gray weathering, subarkosic arenites. Major truncations bound slightly steeper-dipping cosets. Individual sets within the cosets range from 5 to 30 cm. These red beds are possibly eolian. Fresh surfaces are homogeneous, dark gray and recrystallized and these rocks are also hornfels. At the western end of this outcrop the arenites are intruded by Unit 4 quartz monzonite.

In its eastern outcrop areas, Subunit 3b is dominated by sedimentary hornfels. These lie nonconformably upon

tonalitic rocks of Unit 2 or occur as inclusions and pendants, up to 1 km across, within Unit 4. The sediments are mostly fine to medium grained sandstone interbedded with minor quartzites and grits. The bedding in the red beds is usually obscure due to the effects of contact metamorphism. They also contain small granite veins and dikes of pink aplitic to anhedral microgranite and quartz monzonite (Unit 4). It is difficult to differentiate between mottled, salmon pink and white, recrystallized arenites and similarly coloured, subaplitic microgranites. In map area 13E/14, the two lithologies may be intermixed with both irregular and lit-par-lit granitic veining. The hornfels ranges from a chlorite porphyroblastic rock where the red beds are nonconformably on the tonalites, to hornblende-bearing hornfels in some of the pendants and inclusions.

The northernmost outcrop of Unit 3 in the eastern area comprises a sequence of thinly bedded siltstones and a boulder conglomerate. The sequence contains dikes of quartz monzonite and diabase and is bounded to the east by quartz monzonite of Unit 4 in which it is a roof pendant. On its western side a shear zone brings mylonitized quartz monzonite up against the sediments. The granitoid rocks have contact metamorphosed the sediments, which, with the exception of the conglomerate which lies within the shear zone, have remained relatively unaffected by subsequent deformation and greenschist facies metamorphism.

The volcanic rocks in the western area have given a recalculated Rb-Sr isochron age of 1558 ± 60 Ma (Wanless and Loveridge, 1978). The unit is a distinctly younger succession than the type localities of the Petscapiskau Group from which it is temporally separated by the Hudsonian Orogeny. It is proposed that the designation of upper Petscapiskau Group for this sequence be discontinued. A new name will be proposed in a subsequent publication.

Unit 4: Michikamau plutonic suite

Unit 4 underlies the bulk of the southern part of the map area. The earliest members of the unit (4a) are gabbros and their metamorphosed equivalents. Some gabbros are rhythmic and cumulate layered. Typically the gabbros are either hypersthene-bearing, with igneous lamination of plagioclase and hypersthene; or hornblende gabbros, with poikilitic plates of hornblende up to 2 cm across. Diopside may be present as well as augite in some of the gabbros. In places anorthositic layers are present; a particularly thick (3-400 m) anorthosite layer occurs in the outcrop 6 km from the western margin of map area 13L/3.

Most of subunit 4a consists of fine to medium grained, high-level gabbros with intergranular to subophitic textures. There is a range from gabbro and metagabbro to amphibolite in which igneous textures have been all but obliterated and the minerals converted to shape aggregates of plagioclase and amphibole. These variations are typical of the gabbros in map area 13L/6 where the southwestern portion of this outcrop area comprises layered hypersthene gabbros, dipping (and younging) moderately to the east. They are overlain by gabbro and equivalent metagabbro and amphibolite which contain steeply lineated mineral aggregates. The gabbros in the south of map area 13L/3 are quartz-bearing. Those in map area 13L/6 appear to have been a carapace intruded by the later granites which they now ring.

Subunit 4b consists of quartz diorite, quartz monzodiorite and minor diorite. Hornblende usually predominates over biotite and these minerals, together with plagioclase, form the phenocryst phases. The groundmass consists of quartz, microcline, intergrowths of plagioclase and mafic minerals, and opaques. The colour index is 10-25. In most areas Subunit 4b is the first of the granitoid phases to

intrude the gabbros (4a) and locally may be gradational into them (*e.g.* in the southern part of map area 13L/3). Subunit 4b has been intruded by dikes of Subunit 4c. However, the northwestern outcrops of quartz monzodiorite are intrusive into, and contain xenoliths of, the quartz monzonites (4c).

The most abundant rocks of Unit 4 are medium to coarse grained, K-feldspar megacrystic quartz monzonite, quartz syenite and granite (4c). These rocks are massive and pink to gray weathering and characteristically contain feldspar megacrysts. The feldspar is a pink, purplish or gray, usually 0.5 - 3 cm, microcline perthite, with a zoned euhedral form and tiny euhedral inclusions of plagioclase. The megacrysts may reach 7 cm across and often have pink overgrowths which may be continuous into groundmass plates of microcline. Plagioclase is a major phenocryst phase forming euhedral, rectangular laths up to 8 mm in length. The colour index is usually 5-10. The ferromagnesian minerals are biotite and/or hornblende which occur as phenocrysts and in groundmass aggregates with plagioclase. Other groundmass minerals consist of large plates of microcline and anhedral quartz or quartz-microcline intergrowths.

The main facies variants of these rocks are porphyritic or equigranular rather than megacrystic, with K-feldspar mainly restricted to the groundmass. In the westernmost areas of Unit 4, the typical phase is a quartz monzonite in which plagioclase is the prominent phenocryst and porphyritic microcline is very subordinate to groundmass microcline. In map area 13L/6, the rocks vary from coarse grained granite to quartz syenite in which large, anhedral, single or aggregate patches of quartz are similar in size to the microcline phenocrysts.

Magnetite, sphene, epidote and allanite are common accessory minerals in Subunits 4b and 4c. Both subunits are

also characterized by small dioritic and tonalitic xenoliths and dikes of aplite and graphic granite.

Subunit 4d comprises two bodies of alaskite granite intruding the quartz monzonites (4c) in the south of map area 13L/3. K-feldspar occurs as porphyritic (3-5 mm) and occasionally megacrystic (to 2 cm) grains with the same characteristics as those in Subunit 4c. Biotite and magnetite are present only as accessory minerals. The granite bodies are roughly equant and appear to contain no dikes or xenoliths.

Throughout most of Unit 4 the textures appear undeformed. However, the occurrence of folded quartz or epidote veins and the ubiquitous flattened xenoliths attest to a foliation which in the host seems to be manifested only by aligned plagioclase phenocrysts. In areas of stronger deformation the K-feldspar megacrysts also become aligned and plagioclase-mafic and quartz groundmass aggregates are elongated. In map area 13L/6 and in some zones throughout the rest of the area, the aggregates become strongly linear. Partial chloritization of biotite and hornblende and saussuritization of plagioclase occur everywhere. Greenschist facies alteration is most complete in zones of greater deformation where microcline-albite-quartz-chlorite-epidote-magnetite is the resultant assemblage.

Unit 4 is intrusive into all of the older units. Small isolated plutons of both gabbro (4a) and quartz monzonite (4c) cut the gneisses (2) north and east of the main boundary between these two units. Some of the contacts are faulted.

Several dates are available for Unit 4. Quartz monzonites in the southern part, and immediately south, of the map area have given K-Ar ages of 1395 Ma (Fahrig, in Lowdon *et al.*, 1963, page 116) and 1320 $\pm$ 50 Ma (Stevenson, in Wanless *et al.*, 1972, pages 85-86) respectively. In contrast a preliminary

Rb-Sr errorchron on the same rocks has yielded 1700 Ma or older (personal communication, C. Brooks, 1981). Fahrig (in Lowdon *et al.*, 1963, page 116) interprets his age to be the superimposition of a Grenvillian event on older rocks. The older ages on Unit 4 conflict with the 1558 age from Unit 3 into which Unit 4 is intrusive. Isotopic dating of Unit 4 is presently underway and may resolve this problem.

Unit 5: Michikamau anorthositic Intrusion

Unit 5 was studied only near its contact with the country rocks. The anorthositic rocks are coarse to very coarse grained, augite leucotroctolites with equant to rectangular laths of gray plagioclase and poikilitic plates of brown weathering olivine and black augite. The ferromagnesian plates are up to 40 cm across. The colour index is usually 15-20 but both this and the grain size are very variable within and between outcrops. Igneous lamination is poor or absent near the contact but is apparently very well developed further west, as evidenced by transported anorthosite boulders. The leucotroctolites may be heteradcumulates.

Nodular troctolitic rocks outcrop along the shore of Michikamau Lake where they are cut by a host of variably orientated dikes of intergranular-textured, augite troctolite. The latter also contain folded xenoliths of fine grained feldspathic sediment.

The contact with the country rock was not found. No fine grained border phases (Emslie, 1970) were observed, nor were dikes of troctolitic rock found in the country rocks. Xenoliths of country rock are very rare. Much of the contact is probably faulted.

NEOHELIKIAN

Unit 6: Seal Lake Group and equivalent red beds

The red beds of Unit 6 outcrop in

the east of the map area, where they are continuous with the main sedimentary basin of the Seal Lake Group, and at the southern boundary of map area 13L/3.

The red beds in the east of the map area are largely composed of well bedded sandstones with subordinate granule to pebble conglomerate. The sandstones are mainly red and pink, fine to coarse grained, quartz to arkosic arenites. The beds are usually 15-70 cm, plane sided, parallel laminated or crossbedded, tabular sheets. The arenites always display a dark red, recrystallized or well cemented appearance on fresh surfaces. Some sandstones are dark red, more thinly bedded (0.5 - 5 cm) and muddy with scattered medium to coarse sand grains. These finer parts of the sequence also contain dark red siltstones. The arenites are interbedded with gritty layers and matrix supported granule and pebbly sandstones.

The conglomerates consist of well rounded clasts, with moderate sphericity, of quartz, quartzite and minor granitoid rocks. Intraformational clasts of red, muddy sandstone may also be present. Internal characteristics of the conglomerates are large scale crossbed sets, grain size irregularity, and multiple amalgamation surfaces. Rare coarser grained cobble and boulder conglomerates also occur.

East of Mackenzie Lake the outcrops of Unit 6 at the map area boundary consist of gray, feldspathic quartzites interbedded with fine grained, much altered, metabasic flows. The sequence also contains metamorphosed gabbro sills.

At the boundary between 13L/3 and 13E/14, in the south of the map area, matrix supported, cobble to boulder conglomerates and breccias are interbedded with coarse grained, pebbly sandstone. Many of the clasts were apparently derived from Unit 4 lithologies. The clast-bearing beds are overlain by coarse grained, pink arenites with truncation surfaces

bounding large scale, low angle, foreset bedding (?dune bedding). South of the map area this sequence passes up into a series of fining upward alluvial rhythmites (Nunn, 1981b).

An assemblage of calcarenites, stromatolitic limestone, algal-mat breccia, quartz pebble conglomerate, crossbedded quartzite and fine to coarse grained, yellow brown, crossbedded sandstones occurs as boulders of the present day beach deposits around one of the islands in Michikamau Lake. The island itself is underlain by Unit 4. This sequence was not seen *in situ* but stromatolitic limestones have been recorded from the area (Low, 1897). However, their restricted presence around only one island and the local derivation of much of the moraine material throughout the area indicate a nearby source to the west, probably underlying a part of Michikamau Lake. The recrystallized nature of these samples (reminiscent of the red bed arenites) and the nucleation of stromatolites on Unit 4 type granitoid boulders may indicate an association with Unit 6. The presence of stromatolitic limestones in the Seal Lake Group (Brummer and Mann, 1961) also supports a correlation of the Unit 6 sequences with the Seal Lake Group.

Contacts of Unit 6 with other units are largely unexposed. On the shore of Windbound Lake (13E/14), arenite unconformably overlies the granitoid plutonic suite (4) and clast petrology in all areas is consistent with derivation from Unit 4 or similar suites. The alluvial rhythmites just south of the map area boundary are overthrust by Unit 4. In the east of the area the contact with older rock types is fault controlled. The faults are subvertical, trend about 160° and downthrow to the east. The gently undulating red beds are locally steepened into a vertical orientation against the faults.

The red beds of Unit 6 comprise a fluvialite sedimentary facies. The sedimentary structures are considered to represent distal piedmont fan and alluvial plain deposition in a desert environment. In the northeastern part of the map area currents consistently trend towards the southeast quadrant. Around Windbound Lake the source appears to be to the east-northeast. Parts of the sequence may however be eolian. The carbonate assemblage, which may underlie part of Michikamau Lake, indicates passage either laterally or upwards into marine lagoonal and littoral facies or a lacustrine environment.

Other red bed sequences were also examined at the northern and southwestern ends of Michikamau Lake. Petrology, sedimentary facies and relative structural and stratigraphic age relationships indicate that these sequences and the red beds around Windbound Lake should all be correlated with the red beds of south Michikamau Lake (Nunn, 1981a) and with the Seal Lake Group. Lack of facies changes related to the present faulted boundaries of the unit and consistent current directions across the intervening northern gneissic and southern granitoid terrains indicate a formerly continuous outcrop distribution for the unit.

Megacrystic dike

An undeformed, 4 m wide, approximately 065 trending, diabase dike with plagioclase megacrysts, cuts volcanic rocks on the shore of Michikamau Lake. The plagioclase crystals, up to 40 cm across, are broken and corroded. The precise age of the dike is unknown.

QUATERNARY

Surficial geology

Much of the map area is covered by a blanket of Pleistocene glacial till

and outwash and broad bands of rib moraine. Stoss and lee features and striae give an easterly direction for the ice flow. Several northwest trending eskers issue from the higher ground in the northwest part of the area. These join other eskers representing the predominant eastward trend of the drainage during deglaciation.

STRUCTURE AND METAMORPHISM

Hornfelses of Unit 1 adjacent to the anorthositic rocks (5) and west of Michikamau Lake (131/8) were poly-deformed, with development of a strong fabric, prior to contact metamorphism. The fabric is manifested in the mimetic growth of biotite and aluminosilicate minerals and a major quartz segregation which underwent at least two further deformations. The structures, their orientations and the pre- Unit 3 age of these deformations indicate that they are Hudsonian. All the phases of Unit 2 are intrusive into Unit 1 at this crustal level and there is general structural conformity of the fabric across the contacts between the two units. Both Unit 1, which includes the type localities of the Petscapiskau Group, and Unit 2 have therefore been deformed and metamorphosed during the Hudsonian Orogeny and are Aphebian or older.

In the east of the map area the paragneisses are at least as structurally complex as the orthogneisses. No evidence was found of an unconformity between Units 1 and 2, or of older structures, orogenies or basement within the orthogneisses. Both units are therefore assigned to the Aphebian.

The Hudsonian orogeny was a multiphase plutonic and tectonic event. Ninety-five percent or more of Unit 2 appears to have been emplaced between an early deformation period and the main foliation producing episode. The early deformation resulted in development of migmatitic banding and folding (F_1) in the early, dark gray, biotite tonalite and in the Unit 1 paragneisses. These

structures are cut by the main intrusive phases of Unit 2. The rocks then underwent major deformation which resulted, firstly, in an incipient to well developed layering and, secondly, in the production of penetrative LS tectonites throughout the area. The latter, the result of a strong constriction deformation, transposed any fabrics that may already have been present. Folds (F_2) of the layering associated with the rodding deformation are isoclinal. Recrystallization outlasted the deformation in many areas replacing linear mineral fabrics with near isotropic, granoblastic polygonal textures. The rodding is well preserved in rocks containing shape aggregates. The third deformation produced tight to isoclinal folds (F_3), coaxial with the second phase rodding and seems to have affected only areas of gneisses with well developed layering. F_4 structures are open folds with interlimb angles of 90° or more. All these structures have variable orientations due to later tectonic effects. It is not known whether these variations are also Hudsonian or belong to younger orogenic events.

In the eastern parts of the map area dynamothermal metamorphism that accompanied F_2 and the static recrystallization that followed it, occurred at amphibolite facies grade. Posttectonic almandine typically overgrows the biotite foliation in the paragneisses. Northwards, the metamorphic grade was greater and sillimanite grew during syn- and postkinematic crystallization.

In the western part of the map area, and away from the areas of hornfels, the regional grade of Unit 1 is greenschist facies and further north the gneisses of Unit 2 are at amphibolite grade. Other polydeformed sedimentary sequences with Hudsonian trends that occur to the west of Michikamau Lake are tentatively correlated with Unit 1 and show the same range of regional metamorphic grade.

No new mineral growth has been recognized associated with post-F₂ deformation. However, greenschist facies alteration is ubiquitous in the map area and though much of this relates to younger events, some may be due to late Hudsonian retrogression.

Units 3 and 4 contain post-Hudsonian fabrics. Unit 3 is weakly deformed because it was first contact metamorphosed by Unit 4 and thus made resistant to deformation. Unit 4 is also only weakly deformed due to its massive nature. However, both units contain zones of stronger deformation with development of a north-northeasterly trending, steeply dipping foliation. The foliation consists of an SL mineral fabric where it is weakly developed. With increasing deformation, the fabric becomes linear and some of the granites and amphibolites of Unit 4 in 13L/6 display a strong subvertical rodding. The north-northeasterly fabric is not seen in Unit 6 or the anorthositic rocks of Unit 5. As a result the deformation is no longer regarded as an early Grenvillian structure (cf. Nunn, 1981a) and is thought to be Paleohelikian. Unit 4 also contains several thin mylonites of northwesterly to northeasterly orientation that are probably Paleohelikian. The Paleohelikian deformations were accompanied by greenschist facies metamorphism.

Units 4 and 5 have both previously been assigned to the Elsonian plutonic event (Emslie, 1978). Despite the uncertainty of the age of Unit 4, both units predate the Neohelikian Seal Lake Group and are emplaced into and thermally metamorphose Units 1, 2 and 3. Unit 1 in particular displays several well developed contact metamorphic zones. At the contact the unit has been metamorphosed to pyroxene hornfels facies by Unit 5. Pyroxene disappears within about 300 m of the contact, cordierite and sillimanite after about 2 km and andalusite persists to at least 3 km. Within 4 km Unit 1 consists of regional grade, greenschist facies

rocks. Unit 1 was metamorphosed to andalusite grade (hornblende hornfels facies) at the contact with Unit 4 and decreases to chlorite grade within 1 km of the contact. Pyroxene persists in the granulites of Unit 2 for 2 km from the contact with Unit 5 and perhaps more. This may be due to a flat-lying contact in this area. Unit 2 seems unaffected by the granitoid rocks. Three kilometres from the anorthosite contact, Unit 3a volcanic rocks are hornblende porphyroblastic. The presence of epidote and actinolite in patches in the same rock indicates a drop in temperature into the albite-epidote hornfels facies during the crystallization history of the patches. Unit 3 is metamorphosed from chlorite up to hornblende grades by Unit 4.

Grenvillian deformation extends to the north of the map area in Unit 6 where the red beds are gently undulating. Towards the south of the map area, the red beds develop pronounced folds with east-northeasterly axes and eventually become asymmetric with vergence to the north-northwest. No fabrics are associated with these folds.

In map area 13L/3 the red beds of Unit 6 are interbedded with metabasic rocks in which a good northeasterly trending cleavage is developed. A foliation in a zone of strong deformation, with the same northeasterly orientation, cuts the nearby outcrop of Unit 3 arkosic arenites and is also assigned to the Grenville Orogeny. The effect of the zone where it cuts the underlying Unit 2 gneisses is not known. The boundary of the Grenville Province has traditionally been drawn along the contact between the Seal Lake Group and the Unit 2 gneisses in 13L/6 and then arbitrarily extrapolated diagonally across the gneisses underlying 13L/3 before passing south of Michikamau Lake (Smyth and Greene, 1976). However, it has already been determined (Nunn, 1981a) that red beds underlying the southern portion of Michikamau Lake have been thoroughly deformed during a major

east-northeasterly trending Grenville deformation. The granitoid rocks adjacent to these red beds are heterogeneously deformed in an anastomosing network of shear zones with augen preserving pre-Grenville, probably Paleohelikian, structures between them (Nunn, 1981a). This pattern continues to the north into the present map area where the shear zones are narrower and less abundant and the augen larger and coalescing. The Paleohelikian fabric is usually reorientated with a down-dip linear Grenvillian component superimposed on it. Locally, however, the fabric changes only orientation (and not shape) through a shear zone. Hudsonian structures are probably also similarly reorientated in Grenvillian shear zones. However, these Grenvillian reorientations are difficult to separate from earlier strike variations in the gneisses. Superimposed Grenville fabrics have been recognized as far north as Sail Lake. Approximately east-west trending, brittle structures in the area may belong to the same event and some of these may cut Unit 5. Accordingly, the area at least as far north as Sail Lake lies within the Grenville Front Zone (Gower *et al.*, 1980).

ECONOMIC GEOLOGY

A large gossan has been found where northwesterly trending faults cross the Unit 5 contact with the country rocks (Unit 2). The mineralization appears to be hosted by basic rocks; possibly intercalations of Unit 1 in Unit 2. The gossan occurs within an area approximately 1 km² and contains Fe and Cu mineralization. Pyrite is disseminated throughout the basic rocks and the hornfels of Unit 1, and the former also contains Cu staining. No mineralization was found in the rhyolite porphyry conglomerate or the volcanic rocks of Unit 3. The absence of Cu showings in the Seal Lake Group was attributed to the lack of basic intercalations. A hand held scintillometer survey failed to reveal any large areas of particularly anomalous radioactivity; however,

localized at the Unit 2-Unit 3 contact in 13L/3, both the red bed hornfels and the gneisses register two to three times background. A few Unit 2 pegmatites cutting mafic volcanics of Unit 1 also gave readings slightly above background. In general, Units 2 through to 6 seem to have little potential as exploration targets. Unit 1 might prove to have some base metal potential.

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RECONNAISSANCE GEOCHEMICAL LAKE SEDIMENT SURVEY
LONG RANGE MOUNTAINS AREA, NORTHWEST NEWFOUNDLAND

by

James Butler

INTRODUCTION

The reconnaissance geochemical lake sediment survey program for insular Newfoundland was completed during the 1981 field season. The program began in 1972 with orientation studies in the Daniel's Harbour and New Bay Pond areas. In 1973, the first of several seasons of reconnaissance lake sediment surveys commenced with a survey of areas underlain by carbonate rocks of western Newfoundland. The field work for 1981 was conducted in the White Bay - Great Northern Peninsula area (Figure 1).

The eastern and southern limits of the survey area extend from the coast near Ming's Bight south along longitude 56°W to latitude 49°N ; thence west to longitude 57°W , north to latitude $49^{\circ}30'\text{N}$; thence west to the Gulf of St. Lawrence. The area within Gros Morne National Park was not included in the survey, neither were samples collected from the west coast areas of the Great Northern Peninsula nor an area immediately east of Flatwater Pond as these areas were completed earlier (Davenport *et al.*, 1974; Davenport and Butler, 1975).

The total area of the survey is approximately $16,760\text{ km}^2$ and 2,372 samples were collected including 131 replicate samples. A sampling density of one sample per 7.4 km^2 was realized. The sampling and analytical methods have been described elsewhere (Butler, 1980).

GEOLOGY

The central core of the Great Northern Peninsula consists of a Grenvillian Inlier of quartzofeldspathic

gneiss and schist with granite and granite related rocks to the west and north (Figure 2, after Williams, 1967). A profusion of northeast-southwest trending diabase dikes cut the northeast portion of this core. The coastal area to the west consists mainly of Cambrian sandstone, quartzite and shale of the Labrador Group immediately overlain by carbonate and dolomitic rocks of Ordovician age. In the north, the Hare Bay Allochthon of mafic-ultramafic and volcanic rocks rests on Cambrian and Ordovician shale, sandstone and slate.

The White Bay - Sandy Lake section of the area consists of Ordovician carbonates (similar to those on the west side of the Great Northern Peninsula), Silurian volcanic and sedimentary rocks and Carboniferous rocks surrounding a porphyritic biotite granite.

The western part of the Burlington Peninsula is also included in the survey area. This area contains mainly rocks of the Fleur de Lys Supergroup, some Silurian volcanic rocks and several granite bodies including the northern part of the Topsails Granite.

MINERAL POTENTIAL

Several major mining areas are included within the area. Producing mines are located at Daniel's Harbour, where zinc is produced from Ordovician carbonate rocks; and in the Baie Verte area near Rambler Pond, where copper ore is produced from Ordovician volcanic rocks. There is also a producing asbestos mine immediately north of Baie Verte. Past producing copper mines are located in the southeast section of the survey area at Gullbridge and in the

Davis Pond - Whales Back Pond area north of Springdale. Numerous showings and occurrences are recorded in the Springdale - Great Gull Pond area. Other occurrences are located on the west side of White Bay and in the carbonate rocks of the Great Northern Peninsula.

With increasing interest in granitoid rocks, areas of mineral potential would include the granites associated with the core of the Great Northern Peninsula and the northern portion of the Topsails Granite.

OPEN FILE RELEASE

The data collected this year will be released on three sets of element distribution maps for each of Cu, Pb, Zn, Co, Ni, Ag, Mn, Fe, F, Mo, U and L.O.I. (loss on ignition) plus a set of sample location maps on a scale of 1:250,000 with a geological base. Samples collected in 1973 on the Great Northern Peninsula (Davenport *et al.*, 1974) and in 1974 on part of the Burlington Peninsula (Davenport and Butler, 1975) have been reanalyzed and are to be included with the open file release of this season's work.

ACKNOWLEDGEMENTS

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continuing assistance of Wayne Ryder and his staff of Sidney Parsons and Jim Barrett for logistic support is appreciated.

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LEGEND

- C **Carboniferous:** Sandstone, conglomerate, shale.
- S **Silurian:** Sandstone, conglomerate and acidic to mafic volcanic rocks, graywacke; Springdale Group and White Bay rocks.
- O-S **Ordovician-Silurian:** Roberts Arm Group, slate, graywacke, acidic to mafic volcanic rocks.
- O **Ordovician:** (1) Limestone, dolomite, quartzite, sandstone, shale, western Newfoundland; (2) intermediate to mafic volcanic rocks, slate, graywacke, siltstone, chert, conglomerate with minor limestone, central Newfoundland.
- C **Cambrian:** (1) Limestone, quartzite, shale, dolomite, slate, arkose and conglomerate, western Newfoundland; (2) psammitic to pelitic gneiss and schist, marble, quartzite, chloritic greenschist, central Newfoundland.
- CO **Cambrian-Ordovician:** Undivided, shale, sandstone, slate, graywacke, limestone, conglomerate, mafic volcanic rocks.
- H **Helikian or earlier:** Quartzofeldspathic gneiss and schist, psammitic to pelitic gneiss and schist, Long Range Complex.

PLUTONIC ROCKS

DEVONIAN AND EARLIER

- 4 Granite and granitoid rocks
- 3 Gabbro, diorite and related rocks
- 2 Peridotite and alterations of mafic to ultramafic rocks.

HELIKIAN

- 1 Foliated granitic rocks with metamorphic rocks

GEOCHEMICAL FOLLOW-UP STUDIES IN LABRADOR

by

J. McConnell

Field work in 1981 was concerned with obtaining additional soil and rock samples and conducting a VLF-EM geophysical survey over a zinc anomaly in the Labrador Trough 15 km east of Schefferville, Quebec (Figure 1). The work was aimed at investigating the cause of a pronounced zinc anomaly previously detected in lake sediments and waters, stream sediments and waters and in soils. A report on the earlier work was published in 1981 as Labrador Open File 563.

During 1980, stream sediment and waters were collected from areas having anomalously high Zn contents in lake sediments and which are underlain dominantly by shales and slates. Analyses of these water samples were performed in the field using a colorimetric dithizone method. The geometric mean heavy metal content was 4.9 mg/t. A pronounced heavy metal anomaly was defined by a cluster of 37 samples having a mean analysis of 14.9 mg/t and a maximum of 35 mg/t.

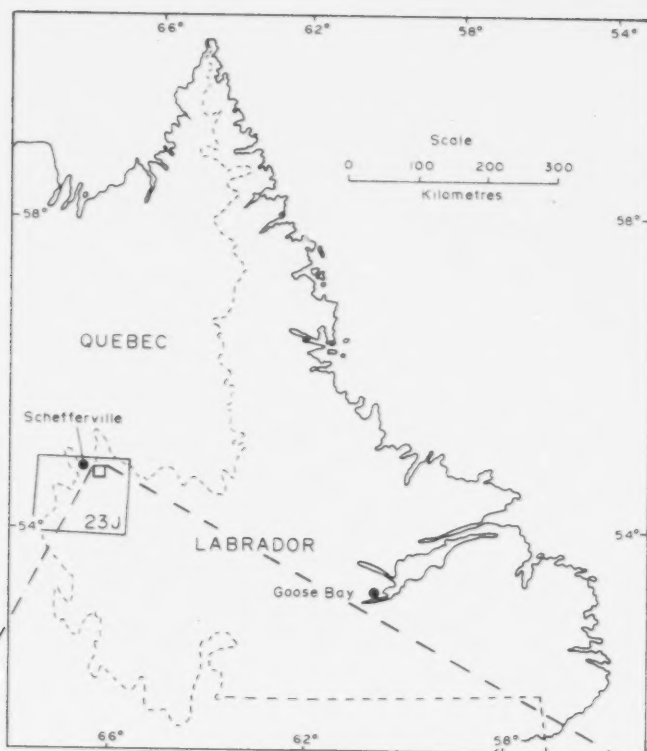
A four square kilometre grid was cut and chained across the anomaly which topographically is of low to moderate relief and covered by a thin till veneer with locally thick lenses. The area is underlain by folded shales and slates of the Menihek Formation, which have been intruded by dikes or sills of Wakuach gabbro. B horizon soil samples were collected at 50 m intervals along lines spaced 400 m apart and running perpendicular to strike. The 235 samples were analysed for Cu, Pb, Zn, Ni, Co, Ag, Mn, Fe, Mo, F, Cd and loss-on-ignition (L.O.I.).

Evaluation of the data indicated several moderately anomalous Zn samples (500-2000 g/t) and an element association of Zn-Ni-Co-Cu-Mn-Mo.

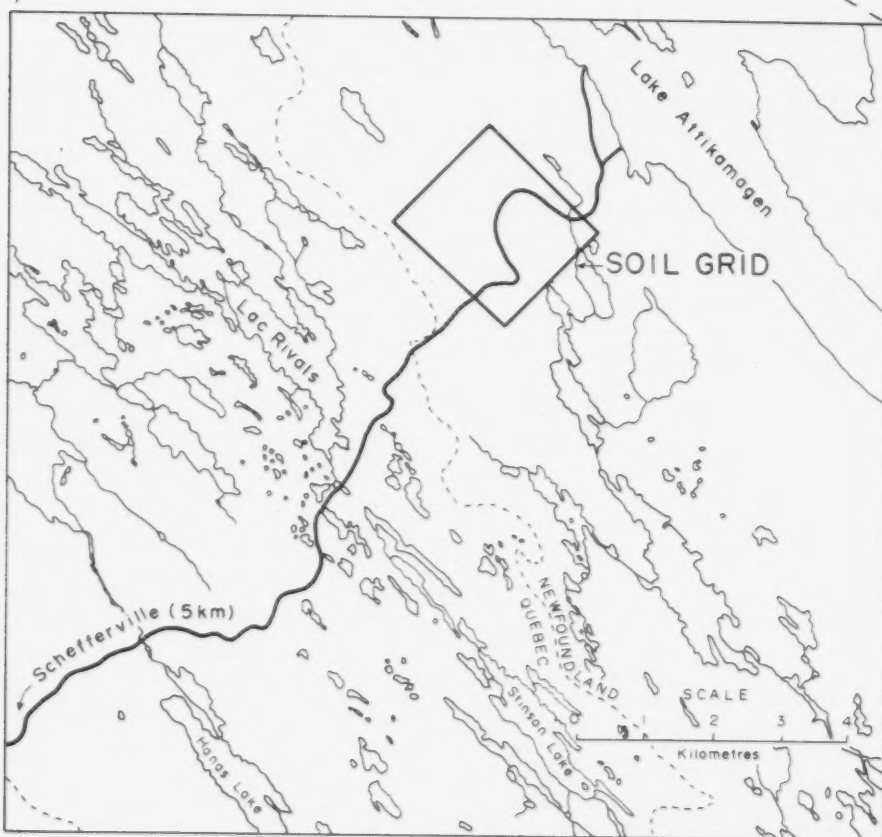
A plot of the raw Zn data yielded a somewhat scattered pattern of high values. Zn residuals, calculated by regressing $\log_{10}$ Zn against $\log_{10}$ Mn and L.O.I. resulted in a more linear pattern of high values approximately parallel to the strike of the shales.

During the summer of 1981, additional lines were cut and chained giving a line spacing of 200 m and 85 more soil samples were collected. Four of these samples have Zn contents ranging from 1400 to 8000 g/t. Areas in the vicinity of the previous year's anomalous samples (as defined both by raw data and Zn residuals) were examined. Sample sites with high Zn concentrations and low Zn residuals often proved to be areas where bog iron or bog manganese ('wad') deposits had formed. This is a poorly consolidated, crumbly brown material highly enriched in Zn, Ni, Co and Mo. The best evidence of bedrock mineralization, on the other hand, was found near a soil sample site which was only moderately anomalous in Zn (700 g/t) but which had the second highest residual zinc score of all the soil samples. A frost heaved block of black shale with thin quartz veinlets adjacent to a frost heaved block of gabbro was sampled. No sulphides were visible in the hand sample but the analysis returned 490 g/t Zn. By way of comparison the mean (geometric) Zn analysis of the 25 shale samples was 90 g/t.

Several samples of pyritiferous shale were sampled. Pyrite occurred both as disseminations and thin laminae conformable with bedding. Rarely, the pyrite occurred as vein fillings. The pyritiferous samples, however, did not carry significant amounts of trace metals. The mean trace element concentrations of the 25 shale samples are listed in Table 1 for comparative



INDEX MAP



purposes with those of the 310 soil samples. Except for F and Pb, the element distributions in the two media are very similar suggesting that the soil geochemistry is, indeed, reflecting the underlying bedrock geochemistry. The discrepancies are likely a function of the relative differences in mobility in the secondary environment.

A VLF-EM survey was conducted over the grid. The resulting data was

filtered, plotted and contoured. Many conductive zones were identified but no obvious correlation with the soil geochemistry patterns could be recognized.

A more complete discussion of this summer's work will be included in a fuller report on geochemical methods of base metal exploration in Labrador to be released this winter.

TABLE 1: Geometric mean concentration (g/t) of trace elements in rock and soil samples.

ELEMENT	SHALE/SLATE SAMPLES	SOIL SAMPLES
Cu	27 g/t	31 g/t
Pb	15 g/t	8.4 g/t
Zn	89 g/t	107 g/t
Ni	30 g/t	18 g/t
Co	5.8 g/t	7.6 g/t
Ag	0.36 g/t	0.37 g/t
Mo	5.3 g/t	3.1 g/t
F	1020 g/t	452 g/t

METALLOGENIC STUDY OF MID-ORDOVICIAN CHERTS AND SHALES OF
CENTRAL NEWFOUNDLAND

by

P.L. Dean and J.R. Meyer

INTRODUCTION

In an effort to introduce new metallogenic concepts and encourage mineral exploration in areas that are presently neglected by the exploration industry, the Mineral Deposits Section initiated an assessment of the potential for sedimentary clastic-hosted metal sulphide deposits in the province. The 1981 program focused on the Mid-Ordovician (Caradocian) cherts and argillites of Central Newfoundland. These strata were deposited in a marine starved basin after the cessation of pre-Caradocian island arc activity. Massive banded sulphides are present in many sections and the stratigraphy and sedimentology of the area compares favourably to basins in which known sedimentary-type stratiform deposits occur.

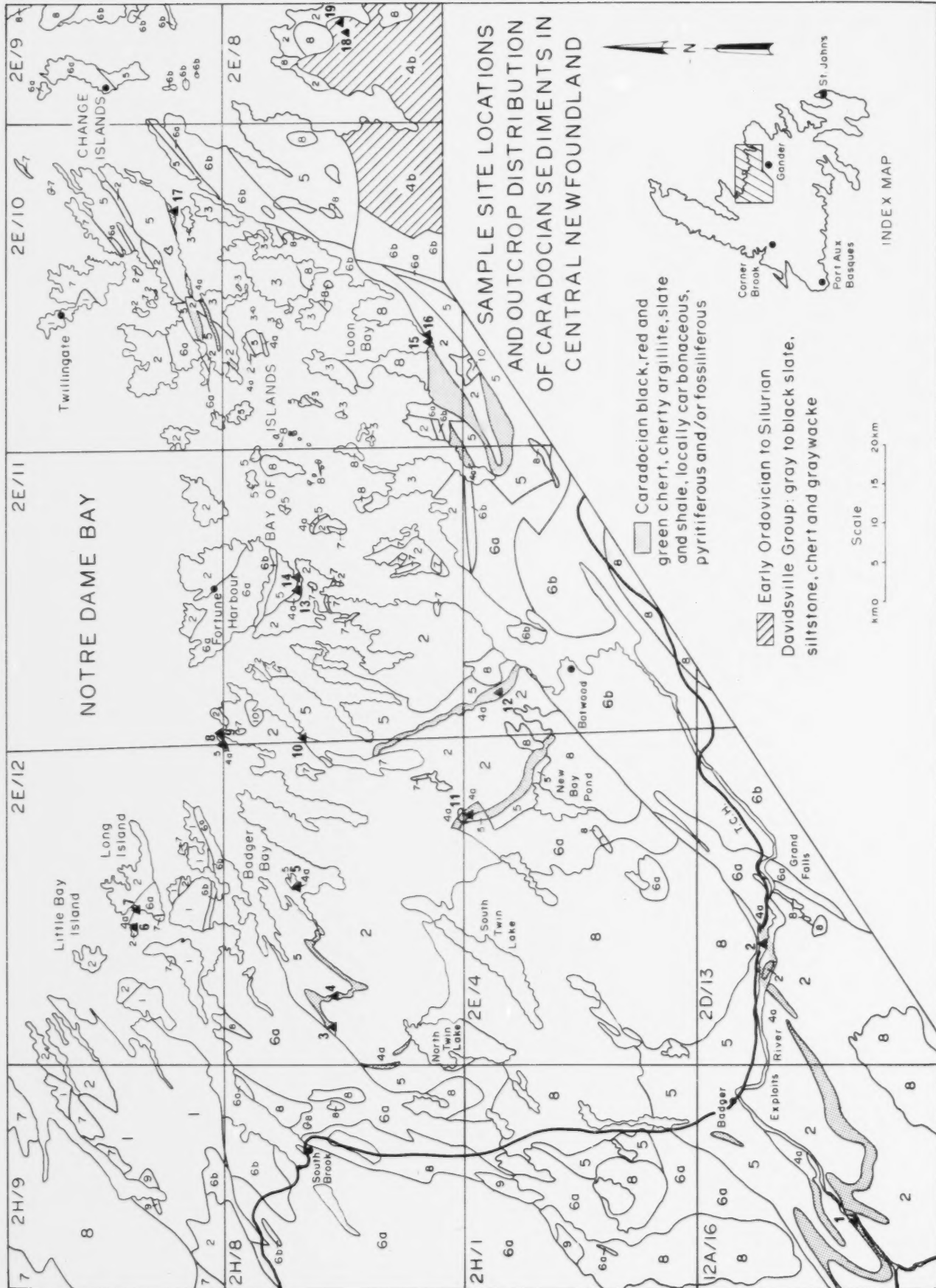
Twenty-four sections were mapped in detail and approximately 1,000 chip samples were collected from 1,500 m of strata. Sample intervals were 3 m in unmineralized sections, 1 m in mineralized sections, and continuous across massive banded sulphides. Sedimentological, structural and paleontological data were collected and rock data sheets were completed to allow entry of all data into computer files. The samples are being analyzed for Cu, Pb, Zn, Ag, Ba, Fe, Mn, C, Ni, Co, As, U and F, as well as major elements. Hopefully, geochemical trends will help delineate sub-basins of metal enrichment within the large Mid-Ordovician basin of Central Newfoundland.

GEOLOGY

The Caradocian cherts and shales are a widespread, distinct stratigraphic

assemblage representing a period of relative quiescence in the geological development of Central Newfoundland. An "immature" pre-Caradocian island arc sequence of alternating mafic pillow lavas and submarine volcanoclastic-sedimentary strata, subsided and was blanketed with Caradocian chert and shale (Dean, 1978). Initial widespread deposition of bedded, bioturbated chert indicates a quiet, clastic-poor marine environment. The chert is overlain by black carbonaceous graptolitic shales, commonly thinly interbedded with black chert. The stratigraphic thickness of the chert and shale varies from 10 m to 200 m, most probably reflecting the paleotopography of the large Mid-Ordovician basin. Conformably overlying flysch deposits were laid down initially in the west of the basin and progressed eastward during late Caradocian times (Dean, 1978). North of the major Lobster Cove - Chanceport Fault in western Notre Dame Bay, Caradocian argillites are conformably overlain by felsic volcanics.

The dominant lithologies of the Caradocian sediments are black, red, and green chert, cherty argillite, slate and shale, with thin to thick interbeds of tuff, graywacke and carbonate. The cherts and shales are particularly rich in banded massive sulphides, which are present in most sections. The lower chert intervals are often strongly manganiferous. The strata are typically steeply dipping and are undeformed to structurally complex. Dikes of various lithologies and ages intrude the chert and shale, some of which may represent 'feeders' to the overlying post-Caradocian volcanics of Central Newfoundland.



LEGEND

10. JURASSIC INTRUSIVES: Gabbros and lamprophyres.
9. CARBONIFEROUS: Conglomerate, sandstone, siltstone and shale.
8. DEVONIAN INTRUSIVES: Granitoids and gabbros.
7. ORDOVICIAN INTRUSIVES: Granitoids, gabbros and diabase sills.
6. POST-CARADOCIAN VOLCANIC ROCKS: 6a, Intermediate to basic pillow lava, breccias and flows; rhyolite and dacite flows; tuff, chert and graywacke; 6b, associated conglomerate, sandstone and siltstone.
5. POST-CARADOCIAN FLYSCH: Graded graywacke, conglomerate and sandstone.
4. CARADOCIAN ARGILLITES: Chert, argillite, shale + graywacke and tuffs. 4a, Shoal Arm Formation, Luscombe Point Formation, Dark Hole Formation, Lawrence Harbour shale and unnamed cherts and argillites of the Exploits Group; 4b, Davidsville cherts, argillites, shales and slates.
3. DUNNAGE MELANGE: Chaotically mixed argillite and pebbly mudstone with large blocks and boulders of volcanic rocks, gabbro graywacke, limestone, micaceous sandstone and granite.
2. PRE-CARADOCIAN ISLAND ARC ROCKS: Alternating mafic pillow lava units and submarine volcanoclastic-sedimentary units.
1. OCEANIC BASEMENT: Massive to pillow basalt, pillow breccia, aquagene tuff and chert, diabase dikes and gabbro.

SAMPLE SITE LOCATION KEY

<u>SITE NO.</u>	<u>SECTION NAME(S)</u>
1.	RED INDIAN FALLS CHERT AND SHALE
2.	RED CLIFF OVERPASS CHERT AND SHALE
3.	WELLS BROOK CHERT
4.	SOPS LAKE CHERT AND SHALE
5.	GULL ISLAND RED CHERT AND SHALE, BLACK CHERT AND SHALE, AND BIOTURBATED CHERT (3)
6.	OIL ISLAND SHALE AND LIMESTONE
7.	LUSH'S BIGHT CHERT AND SHALE
8.	CULL ISLAND BLACK SHALE
9.	LEADING TICKLES SOUTH SIDE RED CHERT AND SHALE
10.	MILL POND SHALE PIT
11.	CAREY LAKE CHERT
12.	CHARLES BROOK CHERT AND SHALE (2)
13.	LAWRENCE HARBOUR ROAD AND SHALE PIT (2)
14.	LAWRENCE HARBOUR SOUTH AND NORTH (2)
15.	LUSCOMBE POINT
16.	LOON BAY ROAD
17.	JOE WHITES COVE
18.	DAVIDSVILLE CHERT
19.	DAVIDSVILLE SHALE

METHODOLOGY

Stratigraphic mapping and sampling of the Caradocian cherts and shales was carried out at 24 well exposed coastal, road, and stream sections throughout Central Newfoundland. Mapping of the sections involved describing sedimentological and structural features, and the types, amount, and mode of visible mineralization. To help accurately date and correlate the strata, graptolites and microfossils were collected wherever possible.

The sections were chip sampled in 1 m and 3 m intervals, according to whether they were mineralized or unmineralized respectively. A mineralized section is defined as one which contains one or more intervals with an estimated 5% or greater sulphide mineralization. Continuous sampling was carried out across massive banded sulphides. The approximately 1000 samples that were collected from 1500 m of strata are being analysed for Cu, Pb, Zn, Ag, Ba, Fe, Mn, C, Ni, Co, As, U and F, as well as major elements. Interpretation will be based on these geochemical analyses, with help from thin and polished sections.

SECTION DESCRIPTIONS

1. RED INDIAN FALLS CHERT AND SHALE SECTION - NTS 12A/16

This is a 124 m steeply dipping, north facing section on the west side of the rapids at Red Indian Falls on the Exploits River. It is approximately 18 km southwest of Badger, and a 1 km hike from Route 370, the Buchans highway. The base of the section is in fault contact with a broad northeast-southwest striking syncline and the top of the section is covered. The lower half consists of gray chert with minor shale and forms a resistant ridge that strikes northeast, perpendicular to the falls. Recessive black shale of the upper half is exposed below and to the west of the falls, and is present in a 6 m

fault-bound unit within the lower chert.

The thin bedded (3 to 30 cm) argillaceous chert and chert are generally bioturbated. Minor light to dark laminations are present and are associated with fine to medium grained graywacke in beds up to 75 cm thick. Discontinuous black shale horizons averaging 5 cm (but up to 1 m thick) are common. Several light coloured tuffaceous shale horizons were noted. Carbonate nodules, lenses and beds up to 5 cm thick are present throughout. There is a partially exposed, well rounded sphere of clastic carbonate (50 cm in diameter) that is very similar to those at the Lawrence Harbour North Section (14b).

The upper shale section is not as well exposed. Its base is in fault contact with very thinly bedded black carbonaceous chert and shale, which are tightly folded and faulted against the lower argillaceous chert. The shale is thickly laminated (5 - 10 mm), carbonaceous, very graptolitic, and heavily iron stained and/or sulphur stained. It contains rare carbonate lenses and rounded clasts up to 50 cm long, and interbeds of fine grained graywacke up to 1 m thick. The shale is mineralized with massive banded pyrite (1 - 4 cm thick), and disseminated pyrite and was sampled at 1 m intervals. The argillaceous chert contains less sulphide and was sampled at 3 m intervals.

2. RED CLIFF OVERPASS CHERT AND SHALE SECTION - NTS 2D/13

On the south side of the Trans Canada Highway, adjacent to the Red Cliff overpass 8 km west of Grand Falls, is a structurally complex section of black chert and shale. The 41 m section was sampled from east to west. Both the top and bottom of the section are covered.

Thin regularly interbedded black chert and shale strike 010° - 175°

(average 145°) and dip generally to the west. They are carbonaceous, commonly graptolitic, and have an extremely blocky fracture. Iron staining and yellow to white sulphur staining is present on many horizons. Fine to medium grained, gray to brown sandstone interbeds are 5 - 100 cm thick, and usually iron stained. They are composed of feldspar, chert, volcanic fragments, and disseminated pyrite. These sandy beds often behave as competent units within the cores of folds. Thickly bedded to massive chert and argillaceous chert dominate the west end of the section where bedding is less pronounced. They contain massive bedded pyrite, and heavily disseminated and fracture-controlled pyrite. Banded pyrite 1 - 10 mm thick is present in some shaley intervals, and one horizon contains pyrite nodules 1/2 - 3 cm in diameter. The section is intruded by fine to medium crystalline, porphyritic intermediate dikes 1 - 3 m thick. Sampling was at 1 m intervals and 4 graptolite collections were taken.

3. WELLS BROOK SECTION - NTS 2E/5

Wells Brook flows southwest into the north shore of Kippens Pond, approximately 15 km southwest of Roberts Arm. The small 25 m section is poorly exposed 250 m upstream from the lake. The bottom and top of the section are covered. Thinly bedded argillaceous chert (maximum 30 cm) is gray, bioturbated and locally carbonaceous. There is extensive fracturing and moderate quartz veining with several intervals showing dense networks of 0.5 - 1.5 mm dark gray quartz veins which strike perpendicular to bedding. Disseminated pyrite and several finely crystalline masses of pyrite less than 1 cm across are present. The section was sampled in two parts at 1 m intervals.

4. SOPS LAKE ROAD SHALE AND CHERT SECTION - NTS 2E/5

Adjacent to the Sops Lake logging road, 4.5 km east of the Kippens Pond

Junction, is a 21 m exposure of black carbonaceous shale and chert. Bedding is not discernable in the lower half of the section and sampling was carried out perpendicular to cleavage which strikes 020° . The top and bottom of the section are covered.

Lenses of chert averaging 5 x 50 mm are squeezed parallel to cleavage in a sheared shale matrix. Quartz pods or lenses are similar in appearance and present in amounts up to 35%. The top part of the section, separated by a 12 m covered interval, is black graphitic shale with a platy parting (1 - 5 mm) and without chert or quartz lenses. Sampling was at 1 m intervals.

5a. GULL ISLAND RED CHERT AND SHALE SECTION - NTS 2E/5

Distinctly red and manganiferous chert and shale are exposed in a 55 m section on the southwest coast of Gull Island in Badger Bay. The section is in two parts separated by a 150 m interval of partially covered outcrop. The base is to the east at the low tide line. To the west, beyond the top of the section, folding and faulting accompanied by large quartz veins and pods, totally disrupts the bedding which outcrops to the southwest edge of the island. The east-northeast striking beds dip 50° - 60° to the north and have prominent cleavage which forms an angle of 60° - 70° with bedding. Folding is apparent between the two halves of the section.

Red argillaceous chert dominates the lower half of the section and is locally cherty or shaley. The thin beds (5 - 25 cm thick) contain dark wavy, discontinuous lenses or laminations, and noncalcareous manganese stained nodules 2 - 5 mm in diameter. Pyrolusite is common on fracture planes and manganese staining is locally very strong, colouring entire horizons silver-gray. Gray-green to white carbonate horizons range from 1 - 15 cm thick (average 3 cm) and the thinner ones are usually stained with manganese. Green to white

tuffaceous horizons are very similar in appearance except for their distinctly strong cleavage. The upper half of the section is gently folded and displays similar lithologies. Tuffaceous, silty and sandy horizons are more common and manganese staining is slightly heavier. The entire section was sampled at 1 m intervals

5b. GULL ISLAND BLACK SHALE AND CHERT SECTION - NTS 2E/5

Black shale and chert on the south coast of Gull Island are very deformed and cleavage is a much stronger fabric than bedding. The 5 - 10 m cliffs were sampled for 75 m, working west to east along the shoreline. There is a large 75 - 100 m break in the middle of the section to avoid resampling strata on the opposite side of a small point. Bedding, for the most part, is vertical and tight local folds and faults may repeat, or omit, parts of the stratigraphic section.

Black to gray carbonaceous or argillaceous chert, and shale are typically very thinly bedded. The chert often appears lensoid and discontinuous in a sheared shale matrix. Iron staining and sulphur staining are common and minor pyrite is disseminated or banded in some intervals. The top 4 intervals of shale and chert are not as badly deformed and graptolites were collected from them. Sampling was at 3 m intervals in this section.

5c. GULL ISLAND BIOTURBATED CHERT AND SHALE - NTS 2E/5

Bioturbated greenish gray argillaceous chert and shale are exposed to the east of the Black Chert and Shale Section (5b), and separated by 150 m of gravel beach. The 36 m northeast striking section is thinly to thickly bedded (maximum 75 cm) and dips 65° to the northwest. The base of the section is covered and to the east, the top ends in the conspicuous core of an anticline, outlined by strong concordant quartz

veining. Cleavage is strong in the more shaley units adjacent to the anticline. Minor manganese staining and several carbonate nodules and lenses were noted. No sulphides were observed in this section and sampling was at 3 m intervals.

6. OIL ISLAND SHALE AND LIMESTONE SECTION - NTS 2E/12

On the northeast corner of the Oil Islands, directly west of Lushs Bight, a 48 m section of calcareous shale and clastic limestone of the Parsons Point Formation is conformably overlain by felsic volcanics of the Long Tickle Formation. This shale has been correlated with other Caradocian shales around Notre Dame Bay (Dean, 1978), and represents the one known visible conformable upper contact with post-Caradocian volcanic rocks. The base of the Oil Island section is covered.

At the exposed base, on the northeast edge of a wave-cut bench, are thinly bedded (maximum 10 cm) calcareous shale and minor chert. They are folded and irregularly interbedded with medium to coarse grained clastic limestone which contains cobbles up to 15 cm in diameter. This is partially eroded by a 10-15 m thick massive unit of fine to coarse grained limestone containing blocks of shale up to 50 cm across. The remainder of the section is gray calcareous shale and limestone breccia which are massive to thinly interbedded. Pyrite is present in most intervals, usually in fine to coarse disseminations but also as euhedral crystals (1 - 3 mm) on fracture planes. Sampling was at 3 m intervals in this section.

7. LUSH'S BIGHT CHERT AND SHALE SECTION - NTS 2E/12

On the west side of Long Island at Lush's Bight, Caradocian argillaceous chert and shale of the Parsons Point Formation are exposed in 6 - 10 m cliffs and on a wave-cut bench on the south side of the harbour. The base of the 9 m

section is covered, and the top is capped by a 2 m porphyritic dacite sill. The Parsons Point Formation is overlain by the Long Tickle volcanics on the Oil Islands (Dean, 1978), but the contact is not exposed here.

Very thinly interbedded argillaceous chert and shale are 1 - 4 cm thick and less than 5 mm thick, respectively. Several 1 - 2 cm thick sandy interbeds, and 4 gray calcareous nodules up to 15 cm across were noted. Fracturing is moderate and carbonate veining is common. Disseminated pyrite is only minor in the small section and sampling was at 3 m intervals.

8. CULL ISLAND BLACK SHALE SECTION - NTS 2E/11

The section is on the south shore of Cull Island, 500 m west of the Leading Ticks causeway. It is a cliff exposure of steeply dipping to vertical black shale and chert. The top and bottom of the 102 m section are covered, as is a 5 m saddle-shaped depression that continues well back from the shoreline and may represent a large fault. Several small faults are evident and a gently dipping, very continuous 1 1/2 m lamprophyre dike cuts across half of the section. The dike has a heavy yellow sulphur precipitate along its edges.

At the base of the section, 18 m of steeply north-dipping bioturbated gray chert and interbedded green tuffaceous shale are faulted against the black carbonaceous shale and chert. The latter are very thinly interbedded, but fracturing and shearing often obliterates bedding. The chert is commonly sheared into pods or lenses up to 40 cm long. The thickly laminated shale is iron stained and often coated with a yellow sulphur precipitate. Disseminated pyrite is present in the chert and one graptolite locality was noted. The sampling was at 3 m intervals.

9. LEADING TICKLES SOUTH SIDE RED CHERT AND SHALE SECTION - NTS 2E/11

This coastal cliff exposure is located east of the south side of the Leading Ticks causeway and continues southeast around the point. The 102 m section consists of upright red and green chert and cherty shale which strike east-northeast. The section is repeated south of the base by folding and faulting. There are tight local folds within the section and much small and large scale faulting. The top of the section is adjacent to the tickle.

Argillaceous chert and cherty shale are in beds averaging 10 - 20 cm thick, with regularly spaced shale laminations up to 1 cm thick. Coarse to fine grained tuffaceous graywacke beds and lenses up to 40 cm thick appear throughout the section. Manganese staining is common and probably derived from the thin carbonate lenses and nodules which are similar in appearance to those at the Luscombe Point Section (15). Sampling was at 3 m intervals and pyrite was observed in two of these.

10. MILL POND SHALE PIT - NTS 2E/6

The 102 m section is in the base of a roadfill shale pit on the east side of Route 350, approximately 16 km north of Point Leamington. Bedding is quite irregular due to the extreme shearing of the very thinly bedded black carbonaceous shale. Three non-parallel 30 m sections were sampled at 3 m intervals across the pit floor. Discontinuous quartz lenses and pods added to the difficulty in sampling the mechanically smoothed surfaces. Disseminated pyrite is common and banded pyrite was observed in the float.

11. CAREY LAKE CHERT SECTION - NTS 2E/5

Carey Lake is 6 to 7 km northeast of Frozen Ocean Lake, downstream along West Arm Brook. The 168 m section is on the southeast side of the lake, and the base is approximately 55°35'0" west

longitude, 49°15'14" north latitude (UTM 603100E and 545660N). It is accessible by logging roads leading north of the Trans Canada Highway to the New Bay Pond area. The base of the section conformably overlies interbedded volcanic flows and chert of the Wild Bight Group. The top of the section is covered, and over 100 m of section in between are covered. The strata are south facing, steeply south dipping, and generally strike 120°.

Red and gray tuffs, mudstones, siltstones and graywacke at the base grade quickly into red and green chert. The chert is thinly bedded to massive and may be intercalated with shale averaging 5 mm in thickness. The upper third of the section is white weathering gray chert that is strongly bioturbated, and still contains shale laminations, many of which are tuffaceous. Moderate manganese staining is present through much of the section and there is disseminated pyrite in several of the 3 m intervals.

12a. CHARLES BROOK SHALE SECTION - NTS
2E/3

Low outcrop is visible discontinuously for 150 m on the west side of Route 350 just north of Charles Brook, approximately 5 km north of Northern Arm. Exposure is poor and rubbly with bedding often parallel to the road. Both ends of the outcrop are covered. The small 5 m section is at the north end of the exposure and consists of gray to black laminated shale which is somewhat carbonaceous, and interbedded with gray medium grained sandstone units 4 - 20 cm thick. Sulphide mineralization is limited to a few 1 - 3 mm bands and disseminations of pyrite. Several species of graptolites were collected from the shale in one of the two sample intervals.

12b. CHARLES BROOK CHERT SECTION - NTS
2E/3

This road exposure is on the east

side of Route 350, 1/2 km north of Charles Brook. Bedding is 135/85 northeast throughout the 60 m section. White weathering gray and black banded chert, in beds average 25 cm thick, is intercalated with laminations of black shale or argillaceous chert up to 1 cm thick. Bioturbation is conspicuous through most of the section with black 'burrow-like' features stretching up to 4 or 5 cm across bedding, but appearing more regularly as 1 - 2 cm wide irregular lenses. Mineralization consists of minor disseminated pyrite and pyrrhotite. The chert was sampled in 3 m intervals.

13a. LAWRENCE HARBOUR ROAD SECTION - NTS
2E/6

On the northeast side of Route 352, about 9 1/2 km south of Cottrells Cove, is a 36 m roadcut section of light to dark green bioturbated chert. The south facing sequence strikes 100° and dips very steeply towards the north end where it conformably overlies small pillowed lavas. The chert beds average 25 cm in thickness and contain fine discontinuous light and dark wavy laminations. There are several thin interbeds of green tuffaceous shale and sandstone. Manganese staining is intermittent and veining is essentially absent. Sulphides were not observed in any of the 3 m intervals.

13b. LAWRENCE HARBOUR SHALE PIT SECTION
- NTS 2E/6

The 22 m shale section is located in the south end of a shale pit on the east side of Route 352, 1/2 km north of the Lawrence Harbour Road Section (13a). The base of the section is covered and beyond the top, the strata are deformed, fractured and heavily veined with quartz. Throughout the section, bedding is a consistent 075° with a vertical dip.

Uniformly black, carbonaceous, graptolitic chert and shale average 3 cm and 1 cm thick, respectively. The shale

has a platy parting (1 - 5 mm), iron staining, and is regularly interbedded with the chert. The black chert is often argillaceous and contains disseminated pyrite. Massive banded pyrite up to 1/2 cm thick, and pyrite nodules (1 - 2 cm across) are present in one interval. Sampling was at 1 m intervals, and graptolites were collected in two of these.

14a. LAWRENCE HARBOUR SOUTH SECTION -
NTS 2E/6

Lawrence Harbour is halfway up the east side of the Fortune Harbour Peninsula and it is accessible by a logging road from the Lawrence Harbour Shale Pit Section (13b). The 52 m section is exposed on a northeast facing cliff and includes several intervals on a wave-cut bench accessible only at low tide. The strata are generally north to northeast facing and dip steeply to the south. Underlying volcanic flows are present 15 m south of the base, across a covered interval. Several folds, faults and covered intervals break the continuity of the section, the top of which is covered.

The lower 10 intervals are light gray laminated and bioturbated chert and shale which contain interbeds of tuffaceous shale and graywacke. There are carbonate nodules and 75 cm long carbonate lenses (up to 3 cm thick) which are slightly stained with manganese. The lower beds grade up into black chert, argillaceous chert, and graptolitic shale. The chert is in beds 1 - 4 cm thick, often squeezed into lenses with long pointed terminations. The black carbonaceous shale averages 1 cm in thickness (maximum 8 cm) and is iron stained. Pyrite lenses (up to 30 cm long) are present in 5 intervals and disseminated pyrite was noted in half of the 1 m intervals. One graptolite locality was sampled and 12 others noted.

14b. LAWRENCE HARBOUR NORTH SECTION -
NTS 2E/6

On the north shore of Lawrence Harbour are sets of broad folds and parasitic folds on a wave-cut bench which is exposed at low tide. The base of the section is at the core of a syncline which plunges very steeply to the south-southwest and the top of the 30 m section is covered. The northwest limb of the fold was sampled at 3 m intervals.

Black weathering, gray to brown, laminated (possibly graded), silty shale occurs in beds up to 25 cm thick. Cleavage is moderate and fracturing slight, despite the degree of folding. Disseminated pyrite was observed in one interval and graptolites in two others. Several horizons contain rounded to elongated limestone spheres up to 2 m in diameter. They are light to medium brown with fine clastic laminations emphasized by differential weathering. The spheres are usually coated with sheared carbonaceous and calcareous mudshale, possibly indicating transport down a paleoslope into the basin.

15. LUSCOMBE POINT SECTION - NTS 2E/7

Thinly to thickly bedded chert, argillaceous chert and shale of the Luscombe Point Formation conformably overlie the pre-Caradocian Loon Harbour volcanics at Luscombe Point in Loon Harbour. The contact is gradational over 10 - 12 m with interbedded light gray chert and gray to green volcanoclastics containing chert fragments up to 5 cm across. The last appearance of the volcanoclastics marks the base of the Luscombe Point section. There are 125 m of strata exposed in the continuous coastal section. It is the best exposed section of Caradocian chert and shale that was sampled. The top of the Luscombe Point Formation is not exposed at this locality.

Dark gray to black chert and argillaceous chert dominate the section. Thin dark coloured laminations are common and bioturbation is present in 10 - 15% of the intervals. Intercalations up to 2 cm thick of light yellowish brown to white, very thinly laminated chert + carbonate, are conspicuous throughout the lower half of the section. The irregularly spaced bands thicken and thin along strike, often in sinuous fashion, and may envelope ellipsoid nodules and lenses which have carbonate cores. These typically weather out leaving black coated cavities. As many as 10 - 15% of the bands are pink and manganiferous, composed of rhodonite and rhodochrosite (Kay, 1975). The upper half of the section contains sets of closely spaced 1/2 - 1 cm resistant white chert laminations which are laterally discontinuous.

Black shale appears as partings or beds up to 8 cm thick (average 1 - 2 cm). They are usually rhythmic in occurrence between thicker argillaceous chert. Rounded to rectangular recrystallized carbonate blocks (up to 20 x 40 cm) are present in the upper shale beds. Several well cleaved green shale horizons, which appear to be tuffaceous, occur in beds up to 17 cm thick, but average 2 - 3 cm. Pyrrhotite + pyrite is disseminated through 80 - 90% of the section. Manganese staining is moderate and there are several groupings of magnetite bands with maximum thickness 1.5 cm. All strata were sampled at 1 m intervals.

16. LOON BAY ROAD SECTION - NTS 2E/7

The section consists of both sides of an extensive roadcut on Route 340, 1.5 km north of the turnoff for Luscombe Point, on the east side of Loon Bay. Chert and argillaceous chert are exposed on cliffs up to 10 m high. The 44 m section on the west side begins 30 m north of the south end at the core of an anticline which plunges 40° to the northeast. The north end is covered. The east section begins 20 m from the south

end where the strata correlate with the top of the west section with a 5 - 10 m overlap. The east section is 113 m, not including two large covered intervals and 3 dikes, 1 - 4 m thick. The top is covered but several small exposures are present north along the road. The Loon Bay Batholith is exposed less than 2 km north of the top of the section. This section is thought to be approximately continuous with the top of the Luscombe Point Section (15). It contains the best exposures of sulphide mineralization of all sections sampled.

The west side consists of thinly to thickly bedded gray chert and argillaceous chert, commonly with sets of resistant white laminations up to 1 cm thick. The chert contains disseminated pyrrhotite and pyrite throughout and is stained with manganese. Upper intervals on the west side display massive well banded pyrrhotite and pyrite + magnetite, across intervals 10 - 40 cm thick.

The east side of the road section begins with similar thinly to thickly bedded chert intercalated with shaley 1 cm bands or thinner partings which occur regularly spaced up to 20 cm apart. These shaley bands are slightly metamorphosed with white mica present on bedding surfaces. Pyrrhotite is often preferentially located in these horizons and also occurs with or without pyrite throughout the east side. There are several tight local folds and faults in the upper half of this side.

Massive banded pyrrhotite and pyrite + magnetite occur throughout a dozen or more intervals on the east side, mostly in the lower half. The bands vary in size from several mm to several cm and are often closely spaced through entire 1 m intervals. Blebs of chalcopyrite up to 5 mm across were present in 2 intervals. Iron and manganese staining is extremely abundant in the sulphide intervals, completely masking the banded nature of the sulphides on weathered surfaces.

Sampling was at 1 m intervals, and 38 of these were selectively resampled at intervals less than 1 m.

17. JOE WHITES COVE - NTS 2E/10

This faulted and folded section is exposed in 5 - 10 m cliffs on the south side of Joe Whites Cove. The cove is on the north coast of Dildo Run, 5 or 6 km northwest of Virgin Arm. The base of the section is on a point at the east end of the cove. Similar rocks are exposed on a wave-cut bench to the east of the point but are structurally repeated strata from the section. The top of the 78 m section is covered at the west end of the cove. Slightly metamorphosed Sansom graywacke is exposed to the north of this covered interval.

Bioturbated gray chert forms the resistant north limb of an anticline which plunges very steeply to the west. The beds are 10 - 25 cm thick with 1 - 2 cm black bands that are increasingly bioturbated to the west. In the nose of the anticline are recrystallized limestone blocks (maximum size 20 x 50 cm). The chert grades west into cherty shale with interbeds of fine to medium grained graywacke. Black carbonaceous, graptolitic shale is exposed at the west end of the cove. It occurs in beds 1 - 3 cm thick, and is extensively sheared and faulted. The shale is coated with a yellow sulphur precipitate and contains disseminated pyrite. Sampling was at 3 m intervals and 2 graptolite localities were sampled.

18. DAVIDSVILLE CHERT SECTION - NTS 2E/8

The section encompasses both sides of a 150 - 200 m roadcut approximately 6 km southwest of Carmanville on Route 330. Bedding is perpendicular to the road, averaging 160/65 east, but the strike folds around to the east at the east end of the south side. The section is within 750 m of the Frederickton Pluton (Currie *et al.*, 1981) and both top and bottom are covered.

Black to gray argillaceous chert (argillite?) occurs in beds up to 1 m thick (averaging 30 cm). Intercalations of shale (1 - 3 cm) are present at regular intervals, but do not always control parting. Coarse metamorphic muscovite (1 - 3 mm) is present on many bedding planes. Quartz veining is slight to heavy, in 1 - 4 mm discordant veins and thicker recrystallized pods. Fine to coarse pyrite appears on fracture and bedding planes, and in lenses up to 10 cm in length and 3 cm across. Pyritized graptolites were noted in one interval. Pyrrhotite is less common, and chalcopryite is present within 1 or 2 small sulphide aggregations. Sampling was at 1 m intervals in this section.

19. DAVIDSVILLE SHALE SECTION - NTS 2E/8

The section is at the south edge of a shale pit on the south side of Route 330, approximately 4.5 km southwest of Carmanville. The 36 m shale section is vertically dipping and strikes 035°. Exposure is rubbly and limited. The shale is black and gray, commonly carbonaceous and in laminations and beds 1 mm to 4 cm thick. Iron staining is common, sulphur staining less common, and slight to moderate quartz veining is present. Graptolites were collected from one interval and noted in the rubble at the northwest side of the shale pit. The shale is mineralized throughout with pyrite + pyrrhotite. The sulphides are usually disseminated but also occur on fractures and in laminations less than 1 cm and lenses up to 4 cm thick. The section was sampled in 1 m intervals.

MINERAL POTENTIAL

The detailed field studies of twenty-four sections of Caradocian cherts and shales substantiated the original hypothesis by Dean (1977) that these strata were deposited in a marine starved basin. The presence of massive banded sulphides in several sections indicate that conditions necessary for

sulphide precipitation existed at various times in various localities in sub-basins, within the major oceanic basin. Preliminary geochemical analyses from several sections indicate considerable relief in contents of Mn, Ba and base metals within the cherts and shales. Careful analysis of the complete geochemical data will hopefully indicate horizons or sub-basins of metal enriched strata and lead to further detailed exploration in these areas.

The raw geochemical data together with stratigraphic sections will be placed on open file after all the analyses are complete.

ACKNOWLEDGEMENTS

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GEOLOGY AND ECONOMIC POTENTIAL OF THE GREAT BURNT LAKE AREA, NEWFOUNDLAND

by

H. Scott Swinden and William T. Collins

INTRODUCTION

The Great Burnt Lake area is defined for the purposes of this report as including the eastern half of the Great Burnt Lake (12A/8) map area and the northeastern quarter of the Cold Spring Pond (12A/1) map area. Geologic mapping at a scale of 1:20,000 was carried out in this area during the 1981 field season as the final part of a three year project to assess the metallogeny and economic potential of the Hermitage Flexure region (see also Swinden, 1980, 1981a).

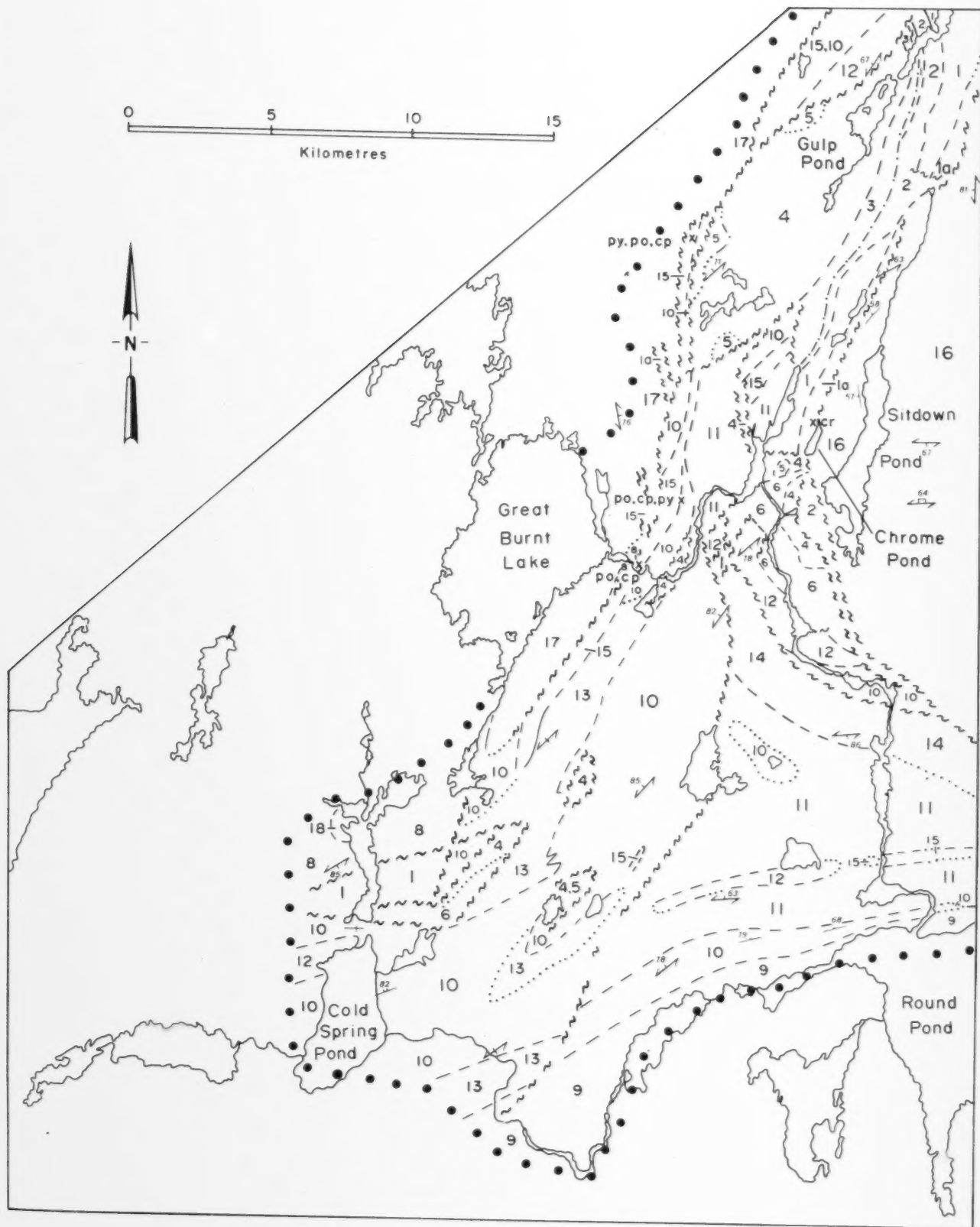
The primary incentive for extending this program to the Great Burnt Lake area was the presence of two massive pyrite-pyrrhotite-chalcopyrite deposits associated with basaltic rocks of the "Great Burnt Lake volcanic belt" (Colman-Sadd and Swinden, 1981). The principal objectives of the mapping were to identify the geologic environment of these deposits, trace the favourable stratigraphy as far as possible and to classify the deposits in the context of similar mineralization throughout central and southern Newfoundland.

In addition, other rock units of possible economic interest were known to be present. Felsic volcanic rocks of the "Huxters Pond volcanics" were known, from mapping to the east by Colman-Sadd (1981), to strike into the area; also, the Pipestone Pond mafic-ultramafic complex was known from previous work to contain chromite showings and possibly to host environments with potential for massive-sulfide deposition. A second objective of the present mapping was therefore to evaluate the geologic and tectonic setting of these rock units in terms of their regional geologic setting and to identify environments of possible economic significance.

Access to the southwestern part of the area between the North Salmon and West Salmon Rivers is provided by all weather gravel roads recently constructed to service the Upper Salmon Hydro Development. This road system connects with public routes in St. Alban's approximately 50 km to the southeast of the map area. The area north and west of the North Salmon River is accessible by float plane via several of the larger ponds or by helicopter; the area north of Godaleich and western Round Ponds is accessible by road and canoe. The North Salmon River provides a convenient canoe route to south-central parts of the area during periods of low water; however, the water level fluctuates considerably depending on the rate of outflow from the Meelpaeg Reservoir and when outflow is high, this can be a difficult and dangerous route. Completion of the North Salmon Dam sometime in 1983 will drastically lower the water levels in this river and perhaps reduce its usefulness as a canoe route.

A comprehensive review of previous work in this area with complete reference to published data and unpublished assessment files can be found in Colman-Sadd and Swinden (1981). The following summary briefly reviews the work which was previously carried out in the area.

The earliest systematic geological work in the Great Burnt Lake area was carried out, not surprisingly, by Alexander Murray, who ascended the Bay East (now known as the Salmon) River in 1870 (Murray and Howley, 1881). He surveyed this river system as far north as Pipestone Pond and Great Burnt Lake and recognized the four principal geologic terrains which underlie the area (see General Geology). He reported



LEGEND

DEVONIAN AND YOUNGER

- 18 Pink equigranular biotite granite.

DEVONIAN AND OLDER

- 17 Granite and granodiorite; moderately to strongly foliated biotite granite and porphyroblastic granite.

LOWER AND MIDDLE ORDOVICIAN

- 16 Thick bedded quartzite and mature graywacke, lesser semipelitic schist often containing andalusite porphyroblasts.

Baie d'Espoir Group (no stratigraphic order implied by sequence)

- 15 Mafic pillow lavas, massive basalt, pillow breccia. Includes considerable fine grained chloritic tuff, lesser fine grained sediments.
- 14 Silicic volcanic rocks; dominantly rhyolitic to dacitic, massive to porphyritic flows and ash flows; local volcanic breccia and agglomerate; minor fine grained sediments.
- 13 Silicic pyroclastic rocks; dark green to black, siliceous tuff with abundant quartz phenocrysts and/or crystal fragments; local concentrations of feldspar and/or lithic fragments.
- 12 Conglomerate; polymictic unstratified to poorly stratified boulder and pebble conglomerate; commonly matrix supported, poorly sorted.
- 11 Silicic tuff and reworked tuff; quartz and feldspar crystal tuff and crystal-lithic tuff; commonly unstratified but locally shows evidence of reworking.
- 10 Sedimentary rocks; includes green, thick to thin bedded graded psammites, siltstones; finely bedded green to black argillites, locally graphitic.
- 9 Salmon River Dam Formation: Thin to medium bedded black to purplish sandstone and siltstone.

ORDOVICIAN AND OLDER

- 8 Psammitic to semipelitic schist and paragneiss.

CAMBRIAN-LOWER ORDOVICIAN

Pipestone Pond Complex

- 7 Black, fine grained sedimentary rocks.
- 6 Basalt; pillowed to massive flows, commonly variolitic, pillow breccia, minor tuff.
- 5 Trondhjemite; coarse to medium grained, equigranular.
- 4 Dominantly coarse to medium grained gabbro; includes fine grained diabase and trondhjemite dikes in higher levels and interlayered pyroxenite in lower levels.
- 3 Coarse to medium grained pyroxenite, locally with interbanded gabbro.
- 2 Banded coarse to medium grained pyroxenite and fine grained peridotite, commonly serpentized.
- 1 Peridotite; fine grained, commonly with pyroxene phenocrysts and disseminated chromite; la, sheared, brecciated and serpentized peridotite.

the presence of chromite and asbestos in the ultramafic rocks west of Pipestone Pond and this was the first account of concentrations of economic minerals in the area.

The chromite concentrations first reported by Murray have received sporadic attention in subsequent years. Good descriptions of the deposits and an assessment of their potential can be found in Snelgrove (1934) and Fogwill (1964).

Early exploration for base metal sulfides in the Great Burnt Lake area was carried out by the Buchans Mining Company in the 1950's. They produced the first comprehensive regional geological maps of the area (Swanson, 1952-1960) and in addition, sponsored detailed mapping of the areas around Sitdown and Pipestone Ponds (Wolofsky, 1951; Slipp, 1952). This exploration was spurred by the discovery of the South Pond copper deposit in 1951 and culminated in the discovery of the Great Burnt Lake copper deposit in 1966. During the years 1967-1970, the area around Cold Spring Pond was explored by the Hansa Syndicate (Sander and Owen, 1968; Sander, 1969; Sander and Heshka, 1970). They carried out airborne and ground geophysical surveys, geochemistry, geologic mapping and diamond drilling but did not locate any significant sulfide concentrations. At about the same time, McIntyre Porcupine Mines were carrying out regional exploration on NALCO concession land in the area around and north of Gulp Pond.

The first published map to include the whole map area was that of Williams (1970) at a scale of 1:250,000. Kean (1974) examined the ultramafic parts of the Pipestone Pond Complex during his assessment of the economic potential of ultramafic rocks in eastern Newfoundland. Geologic maps at a scale of 1:20,000 resulting from the present mapping have previously been released on open file by the Newfoundland Department of Mines and Energy (Swinden, 1981b).

Exploration in the area in recent years has been relatively active. Abitibi-Price continue to carry out sporadic exploration on the mining lease which includes the South Pond and Great Burnt Lake deposits. Other companies which have acquired ground and/or filed recent assessment reports in this area include Riocanex, Consolidated Morrison, Shell Canada and Minorex.

GENERAL GEOLOGY

Four geologic terrains are represented in the Great Burnt Lake area. From west to east, these are: (1) an igneous/metamorphic terrain comprising equigranular to porphyritic granite, deformed, commonly porphyroblastic granite and psammitic to semipelitic paragneiss and schist; (2) volcanic and sedimentary rocks provisionally assigned to the Baie d'Espoir Group; (3) ultramafic and mafic rocks, assigned to the Pipestone Pond complex, which display ophiolitic stratigraphy; and (4) unnamed quartzites and semipelitic schists which show a steady increase in regional metamorphic grade towards the east. These four geologic terrains are fault bounded at their mutual contacts and, in addition, all are disrupted internally by faulting. Stratigraphic correlations between terrains (and often within them as well) may therefore be somewhat tenuous. The geologic units are described below in order of decreasing age.

OPHIOLITIC ROCKS (UNITS 1-7)

A sequence of mafic and ultramafic rocks, termed the Pipestone Pond complex, underlies a crescent-shaped area between the Jamieson Hills to the south and the northeast boundary of the map area. Similar rocks are known to extend into the Burnt Hill area to the east (Colman-Sadd, 1981) and into the Noel Paul's Brook (Kean and Jayasinghe, 1980) and Miguel's Lake (Colman-Sadd and Russell, 1982) map areas to the northeast. The sequence displays a

complete ophiolitic stratigraphy but is considerably disrupted by internal faulting such that no single section through the sequence traverses the complete stratigraphic section. The ophiolite faces west and a reconstructed stratigraphic section would consist of, from east to west: peridotite; banded peridotite/pyroxenite; pyroxenite and banded pyroxenite/gabbro; gabbro grading into diabase and cut in the upper levels by dikes of diabase, pegmatitic gabbro and trondhjemite; mafic pillow lava and isolated pods of fine grained clastic sedimentary rocks. Where ultramafic rocks occur adjacent to the boundary faults, they are commonly highly sheared and serpentinized.

Unit 1 consists of massive, brown weathering peridotite which forms a prominent outcrop band east of Gulp Pond and a less well exposed belt east and northeast of Pipestone Pond. Chromite is ubiquitous in this rock, generally as finely disseminated grains, less commonly as blebs up to 2 cm in diameter and rarely as pods and lenses up to 3 m long. Phenocrysts of pyroxene are commonly present in amounts ranging from less than 0.5% to 4%. The peridotite exhibits no obvious tectonic fabric although most outcrops carry widely spaced fractures that are commonly serpentinized. A subtle banding composed of chromite enriched horizons is rarely developed.

Peridotite forms the eastern boundary of the ophiolite north of Chrome Pond and, adjacent to the boundary fault, it is commonly highly sheared and serpentinized (Unit 1a). The serpentinized peridotite weathers a distinctive red and is characterized by a well developed fracture cleavage, intense shear and breccia zones and local development of talc-carbonate schist. Minor amounts of asbestos are rarely developed on shear surfaces and some exposures are injected by myriads of quartz veins and stringers. Similar features are developed near the narrows on Pipestone Pond where the west boundary fault cuts peridotite as well.

The peridotite grades westward into a unit of banded peridotite and pyroxenite (Unit 2). The pyroxenite is generally coarse grained, with individual crystals up to 2 cm, and weathers a pale green, whereas the peridotite is commonly serpentinized, fine grained and weathers a bright red-brown. In the Jamieson Hills, this unit is the lowest stratigraphic unit exposed and is faulted to the east against sediments of Unit 16. West of Gulp Pond, it is gradational with peridotites of Unit 1 and passes westward into dominantly finer grained pyroxenite/gabbro of Unit 3. A sliver of unaltered peridotite outcrops in a narrow band east and northeast of Gulp Pond on the west side of Unit 2; it is not clear whether this is a conformable pod occurring slightly higher in the stratigraphy than usual or whether it is a faulted-in slice from lower levels in the ophiolite.

The banding in Unit 2 occurs at scales ranging from centimetres to tens of metres. On outcrop scale, peridotite and pyroxenite commonly form bands of 5 to 50 cm wide. Locally the coarse pyroxenite appears to intrude the serpentinized peridotite; in other cases, this relationship is not clear. Mega-banding is best developed in the Jamieson Hills where individual bands up to 100 m wide can be mapped. West of Gulp Pond, the banding is generally on a finer scale of 1 to 100 cm. As a general rule, the ratio of pyroxenite to peridotite in Unit 2 increases to the west until the latter lithology disappears. The last westward exposure of peridotite is taken as the boundary between Units 2 and 3.

Unit 3 consists of pyroxenite and banded pyroxenite/gabbro. It is principally a transitional unit between the ultramafic rocks of Units 1 and 2 and the mafic sequences (Units 4-6) to the west. Pyroxenite without gabbro forms a relatively narrow band along the eastern boundary of Unit 3 east of the last exposures of serpentinized peridotite. Gabbro first appears as a

minor component in the eastern part of Unit 3 and gradually increases in abundance towards the west. Gabbro and pyroxenite are generally interbanded on outcrop scale in the western part of Unit 3, and dikes of fine grained gabbro cut the pyroxenite as well. The western contact with Unit 4 is very gradational and is drawn to reflect the point at which gabbro becomes more abundant than pyroxenite; as such, it is a fairly subjective boundary.

Gabbro and associated rocks which make up Unit 4 outcrop in two areas within the Pipestone Pond complex. Northeast of Pipestone Pond, they form an elongate body which can be traced northeastwards to the vicinity of Gulp Pond whereas southeast of Pipestone Pond in the Jamieson Hills, they form a relatively thin unit directly underlying the pillow lavas of Unit 6. In the northern lens, the principal lithology is medium to coarse grained gabbro. In the eastern (lower) parts of this lens, the gabbro is interbanded with medium to coarse grained pyroxenite on both outcrop and larger scales; the incidence of pyroxenite gradually decreases westward until it dies out. The western (upper) part of the gabbro body is cut by dikes of diabase, pegmatitic gabbro and trondhjemite. The diabase dikes are commonly multiply injected along parallel tracks and may comprise up to 50% of some outcrops. They are generally not sheeted in the sense that dike-within-dike features can be recognized; however, parallel dikes are locally seen to share a mutual contact along which screens of gabbro may be preserved. Pegmatitic gabbro is a common constituent of Unit 4 southwest of South Pond. It consists principally of very coarse plagioclase and pyroxene crystals (up to 10 cm) and locally contains coarse blebs of magnetite as well. It occurs as dikes cutting gabbro and diabase and locally comprises entire outcrops. A third common intrusive phase cutting the gabbros is trondhjemite which generally forms dikes and pods within the gabbro and appears to cut

most other mafic phases as well. Locally, it forms large pods which can be separated as distinct map units (Unit 5).

In the Jamieson Hills, Unit 4 is commonly fine to medium grained and would generally be more properly termed diabase. Many of the outcrops, particularly close to the contact with pillow lava, are very fine grained, green outcrops with little or no recognizable texture or structure. Surfaces are deeply weathered and lichen covered and it is possible that sheeted dikes in this area could pass unrecognized. However, an unfaulted contact between gabbro and pillow lava is exposed on a hill southwest of Chrome Pond and at this locality, medium grained gabbro forms the intrusive phase. Here, at least, sheeted dikes are not developed between gabbro and volcanic members of the ophiolite.

Trondhjemite locally forms large pods in the upper levels of the gabbro which can be separated as distinct map units (Unit 5). The trondhjemite is commonly medium to coarse grained, composed of plagioclase, mafic minerals (up to 20% but commonly less) and quartz phenocrysts (up to 10%). Three pods have been outlined in the northern gabbro lens northwest of Pipestone Pond and a fourth in the area on the north flank of the Jamieson Hills.

Pillowed and massive basalt (Unit 6) overlies the fine grained gabbro and diabase southeast of Pipestone Pond and is particularly well exposed along the shore of the North Salmon River. It is generally composed of large, well formed pillows up to 1.6 m long, which are commonly vesicular and display spectacular variolitic texture at some localities. Pillow breccia is a common constituent of Unit 5 as well. Little or no chert or hyaloclastic material is developed in the pillow interstices.

A few exposures of black, fine grained sediments (Unit 7) are present

in the pillow lavas along the North Salmon River. These rocks are generally highly sheared and of limited aerial extent; they may represent the highest exposed level of the ophiolitic stratigraphy or, alternatively, may be younger sediments introduced along faults.

Ophiolitic rocks which are not strictly part of the Pipestone Pond complex occur throughout the map area as small, fault bounded pods. The largest of these, which underlies the area north of Cold Spring Pond, contains several elements of ophiolitic stratigraphy; most, however, are very local in extent and contain only one or two rock types of ophiolitic derivation.

The Cold Spring Pond fragment is poorly exposed but appears to consist of at least three fault bounded slices. Peridotite and sheared, serpentinized peridotite occupy the northwest part of the fragment, the dominant lithology being massive, brown weathering peridotite very similar to that east of Gulp Pond. The western part of this fragment is underlain by medium to coarse grained gabbro and trondhjemite which is lithologically similar to rocks exposed in the upper parts of the gabbro lens northwest of Pipestone Pond. The gabbro and ultramafic lithologies are bounded to the south and southeast by sheared and deformed pillow lavas which are interpreted, on the basis of their association with gabbro and peridotite, to be ophiolitic; however, it is possible that they comprise part of Unit 15 basalts within the Baie d'Espoir Group and are unrelated to the ophiolite. Whole rock geochemical studies directed towards a better definition of this relationship are in progress.

Ophiolitic rocks outcrop in two small pods northeast of Cold Spring Pond and east of the North Salmon Dam access road. Both consist dominantly of medium

grained gabbro, diabase and trondhjemite, although the more northerly of the two also contains some sheared, serpentinized peridotite. A third large pod of mainly gabbroic rocks outcrops along the North Salmon River immediately east of the North Salmon Dam. The structural setting of these three gabbroic pods and of the Cold Spring Pond fragment is not clear. It may be that the faults which bound these fragments continue to the northeast and southwest beyond the limits of the ophiolitic lithologies. In this case, the trace of the faults will be extremely difficult to recognize, as the faults would be separating similar lithologies, and exposure is not good enough to expect the actual faults traces to outcrop. Alternatively, the ophiolitic rocks may be exposed in windows formed either through upward doming or folding of underlying strata; in this case, the bounding fault traces would not extend beyond the margins of the windows. If this latter interpretation is true, it would imply that ophiolitic rocks structurally underlie all rocks west of the Pipestone Pond complex to the limits of present mapping. There is, at present, insufficient evidence to resolve this problem.

Very small pods of ophiolitic, dominantly ultramafic, rocks appear along fault traces in the northern part of the map area, particularly in the area near and north of the North Salmon River. Single outcrops of sheared peridotite within the younger volcano-sedimentary sequences commonly mark the traces of major faults and it appears that this lithology has been particularly amenable to being mobilized along these faults. It should be noted that whereas ophiolitic fragments are very common in sequences to the west of the Pipestone Pond Complex, no such fragments are found in the quartzite/semipelite sequence east of the ophiolite (Unit 16).

METASEDIMENTARY AND METAVOLCANIC ROCKS (UNIT 8)

Metasedimentary and metavolcanic rocks of Unit 8 are irregularly distributed throughout the igneous/metamorphic terrain at the western edge of the map area. The most northerly exposures of this unit form a thin band northeast of Great Burnt Lake and comprise medium bedded quartzite and mature graywacke interbedded with garnet- and andalusite-bearing semipelitic schists. Quartzite forms the dominant lithology with beds up to 30 cm thick separated by thin semipelitic units. The original lithology would probably have been very similar to quartzites of Unit 16 which outcrop in the Sitdown Pond area.

Near the North Salmon Dam, a thin band of semipelitic schists are faulted against pillow lavas of the Baie d'Espoir Group. These are well exposed in road cuts along the North Salmon Dam access road and in shoreline outcrops along the North Salmon River. The latter outcrops show some migmatization with development of feldspar porphyroblasts and incipient gneissic banding.

South of Great Burnt Lake, migmatized metasediments and metavolcanics are widespread. Micaceous, garnetiferous psammitic rocks are the dominant lithology and are intercalated with lesser semipelitic rocks. All exhibit tight polyphase folding and extensive injection of quartz. Recognizable volcanic rocks are rare but northwest of Cold Spring Pond, sericitic schists with quartz phenocrysts and massive, white to buff, siliceous rocks may signal a felsic volcanic protolith.

The age of the rocks which comprise Unit 8 is not known with certainty. They are similar lithologically and probably equivalent to schists, gneisses and migmatites which outcrop extensively throughout the south central part of the Central Mobile Belt (*e.g.* Unit 3b of Kean and Jayasinghe, 1980; Units 3c and

3d of Kean and Jayasinghe, 1981; Unit 1 of Dickson and MacLellan, 1981). These are generally considered to be highly metamorphosed equivalents of the Ordovician sedimentary/volcanic packages which are extensively developed throughout the Central Mobile Belt.

BAIE D'ESPOIR GROUP (UNITS 9-15)

Volcanic and sedimentary rocks which lie immediately west and south of the Pipestone Pond complex are assigned to the Baie d'Espoir Group. These include rocks which are on strike with sequences previously mapped as Baie d'Espoir Group in the Burnt Hill area to the east by Colman-Sadd (1981) as well as a northeast-trending belt in the western part of the area previously referred to as the "Great Burnt Lake volcanic belt" (Colman-Sadd and Swinden, 1981). A considerable variety of rock types are represented in the Baie d'Espoir Group in this area, ranging from felsic and mafic volcanic rocks to medium and coarse grained clastic sediments. Because of tight folding and paucity of facing criteria within these sequences, relative stratigraphic positions of the various stratigraphic units are not entirely certain; no stratigraphic order is implied by the position of these units in the legend of the accompanying map, nor by their order in the following discussion, except where specifically stated.

The Salmon River Dam Formation (Unit 9), which underlies the southeastern corner of the map area, is continuous with exposures previously mapped in the Twillick Brook and St. Alban's map areas to the southeast by Colman-Sadd (1976, 1980). It is well exposed in the bed of the West Salmon River southwest of Godaleich Pond and in the tailrace below the Godaleich Pond power house. It consists of dense, fine grained, black to dark gray, finely laminated sandstone. Crosslaminations, ripples and scour and fill are all common. Coarse beds up to 30 cm thick are characteristic of this unit whereas

fine laminations on the scale of 10 to 30 mm can be seen in good exposures. Little or no pelitic material is present. The contact with green turbidites of Unit 10 (North Steady Pond Formation) to the north is exposed in the tailrace immediately northwest of Godaleich Pond; it appears to be a conformable sedimentary contact modified by later shearing. Colman-Sadd (1980) has argued on regional stratigraphic grounds that the Salmon River Dam Formation is the basal unit of the Baie d'Espoir Group and therefore should underlie the North Steady Pond Formation. Facing directions are ambiguous in the present area and this was not confirmed or denied.

Units 10 to 15 are probably equivalent to the North Steady Pond Formation as defined by Colman-Sadd (1980). A formal proposal regarding the nomenclature will be made in a forthcoming publication.

Unit 10 consists principally of clastic sedimentary rocks. The main lithologic type is dark green phyllite and psammite displaying crossbedding, scour and fill and ripples. The psammites are generally finely laminated and have beds from 1 to 30 cm thick. This rock forms the bulk of the succession in the northeast trending belt extending from east of Great Burnt Lake to the limits of mapping west of Cold Spring Pond. Gray to black slate and graphitic slate are interbedded with the sandstones and are locally somewhat pyritic. Partial Bouma sequences (Bouma, 1962) are preserved locally, especially near Cold Spring Pond where fine grained turbidites are more prevalent.

An east/west band of fine grained sedimentary rocks which crosses the southern part of the map area north of Godaleich and Round Ponds is also assigned to Unit 10. These rocks comprise relatively fine grained, green sandstones and phyllites displaying well developed partial Bouma sequences with lower graded psammitic beds up to 4 cm

thick overlain by thin silty and slaty beds. These rocks are similar to North Steady Pond Formation turbidites described by Colman-Sadd (1980) in the Twillick Brook area. As previously noted, this unit is in conformable contact with the Salmon River Dam Formation to the south. It grades northward into tuffs and arkoses of Unit 11 and appears as lenses in this latter unit.

Along the North Salmon River south of Sitdown Pond, turbidites of Unit 10 gradationally overlie coarse conglomerates of Unit 12 and appear to form the cap of a very large debris flow deposit. In this area, coarse sandstones displaying classic Bouma sequences directly overlie the thick conglomerate unit and grade southwards into finer grained, more distal turbidites consisting of graded sandstones and siltstones with interbedded shales.

Colman-Sadd (1980) has previously noted that sediments of the North Steady Pond Formation contain mainly volcaniclastic debris and appear to have been derived from erosion of the central Newfoundland island arc. This interpretation would appear to be valid for sediments of Unit 10 in the present area as well.

Unit 11 consists of massive, generally structureless, crystal and crystal-lithic tuff, reworked tuff and volcaniclastic lithic arkose. It outcrops in a wide, east/west trending belt north of Round and Godaleich Ponds where it is on strike with similar rocks of the North Steady Pond Formation mapped in the adjacent Burnt Hill map area (Colman-Sadd, 1981), but unseparated from turbidites in the Twillick Brook map area (Colman-Sadd, 1980). It also occupies a northwest-southwest trending belt immediately west of Pipestone Pond where it is in fault contact with the Pipestone Pond complex. Unit 11 lithologies are commonly massive, hard, siliceous rocks which are relatively resistant and form good

exposures through most of their mapped extent. The dominant lithology comprises 5-30% quartz and feldspar crystal fragments set in a pale green, very siliceous groundmass. Lithic fragments are less commonly present, but are locally the dominant clast lithology; where present, they are generally volcanic in origin. Fragments range from less than 1 mm to pebble size. Stratification is generally not recognized in outcrop although rare exposures may exhibit a faint layering on the scale of metres which reflects slight differences in grain size distribution. This, and the rounding of crystal fragments, suggests that some resedimentation has taken place.

Tuffs and arkoses of Unit 11 are closely associated with pebble to boulder conglomerates which make up Unit 12; these conglomerates form lenses which are sometimes of mappable scale within the finer grained rocks. There appears to be a continuum between coarse grained, pebbly arkosic rocks of Unit 11 and the finer grained varieties of Unit 12 conglomerates.

North of Godaleich Pond, Unit 11 lithologies are intercalated with green turbidites of Unit 10. To the north, their contact with silicic volcanics of Unit 14 is not exposed but appears to be conformable, marked by a thin band of dark gray to black pelitic sediments. West of Pipestone Pond, Unit 11 appears to pass conformably to the west into mafic volcanics and volcanoclastic sediments.

The origin of the rocks which make up Unit 11 is not clear. Although some evidence of reworking is present locally, they generally show little evidence of deposition by sedimentary processes. The abundance of quartz and feldspar and volcanic lithic clasts suggests that these rocks are derived from a volcanic terrain and it is suggested that they may be tuffs which were rapidly deposited and slightly reworked in the vicinity of contemporaneous volcanism.

Unit 12 consists of poorly sorted, pebble to boulder conglomerates. They form two thick, continuous units, one along the North Salmon River south of Pipestone Pond and the other in a series of prominent ridges west of Gulp Pond. As well, the conglomerate forms lenses within the tuffs and arkoses of Unit 11. Most of these conglomerates consist of 30 to 75% poorly sorted clasts which include, in decreasing order of abundance, quartz, felsic volcanics, mafic volcanics, sedimentary rocks, granite and gabbro and black chert. The clasts are set in a green, fine to medium grained, volcanoclastic matrix. The conglomerates are generally matrix supported and do not normally display stratification, imbrication or other sedimentary structures. However, locally, a crude stratification consisting of broad scale clast size grading or the presence of isolated boulder beds is evident; this is best developed in exposures along the North Salmon River near the gradational contact of the conglomerate with the overlying turbidites. The conglomerates are generally quartzose with subrounded quartz grains occurring as pebble sized clasts. Volcanic and sedimentary clasts are generally angular to subrounded; granitoid and gabbroic clasts (where present) tend to be both larger and more rounded than the accompanying clast assemblage.

The conglomerates in this area appear to have formed as debris flows; the clast assemblage suggests that these flows were sampling both the early stages of the central Newfoundland island arc as well as the older ophiolite. The origin of the granitoid clasts is not certain, although they may be trondhjemite related either to ophiolite or island arc processes. Further petrographic and geochemical studies will be directed at this problem.

Unit 13 consists of crystal and crystal-lithic tuff which outcrops as a series of northeast trending lenses southeast of Great Burnt Lake. It is

best exposed in road cuts along the North Salmon Dam access road. Felsic tuffs of Unit 13 are quite different from those of Unit 11; they consist generally of a dense, dark gray to black, aphanitic, very siliceous matrix with 1 to 15% quartz eyes varying in size from 1 mm to 10 mm. Locally, lithic fragments are present and some phases contain feldspar phenocrysts as well.

The felsic tuffs of Unit 13 display little variability along strike. However, in the area immediately south of the North Salmon River, they pass northwards into dense, white, massive rhyolitic rocks which appear to be flows rather than pyroclastic rocks. This may signal the proximity of a volcanic center in this area. The band of Unit 13 lithologies which outcrops in the southwest part of the map area tends to be less siliceous than the lenses to the north and consists of 1-5% quartz eyes set in a black, chloritic matrix. These tuffs are interbedded with conglomerates in the bed of the West Salmon River.

Felsic volcanic rocks of Unit 14 outcrop in a 1 1/2 km wide, east-west trending belt across the southeastern part of the map area. They are correlative with rocks in the Burnt Hill area referred to by Colman-Sadd and Swinden (1981) as the "Huxters Pond volcanics". Two lithologies predominate in this unit; the first is massive pale green rhyolitic flows and ash flows which are commonly aphanitic and exhibit flow banding and flattened pumice fragments in well washed exposures. The second lithology comprises a more mafic-looking rock, dacitic to intermediate in composition, consisting of a pale gray, siliceous groundmass with 20-30% feldspar and quartz phenocrysts. Coarse rhyolitic agglomerate and/or volcanic breccia is present locally, consisting of angular to subround rhyolitic fragments set in a fine grained silicic tuff matrix and suggesting proximity to a center of explosive volcanism.

The felsic volcanics are interbedded with and bounded to the south by fine grained gray to black, water-lain clastic sedimentary rocks. The volcanic rocks themselves contain flow banding and pumice fragments suggestive of deposition in a subaerial environment and it seems likely that during this volcanic episode, both subaerial and submarine deposition were taking place in close proximity, perhaps in a volcanic island environment. The environment would therefore seem to have been favourable for volcanogenic sulfide deposition. In this regard, some horizons in the volcanic sequence are locally highly sericitized and silicified and contain patches up to 3 m in diameter which carry 0.5 to 3% disseminated pyrite. No base metals were noted in these occurrences. Similar occurrences have been reported by Colman-Sadd (1981) in felsic volcanics in the Burnt Hill area.

Unit 15 comprises mafic volcanic rocks, including massive basalt, pillow lava and fine to medium grained mafic tuffs. These rocks are most extensively developed immediately east and northeast of Great Burnt Lake where they can be traced along strike for more than 18 km. Mafic flows which make up the bulk of Unit 15 are well exposed in new quarry and working sites near the North Salmon Dam, where they comprise both massive basalt and pillow lava which is made up of large (0.75 to 1.5 m) pillows which show little evidence of flattening. Hyaloclastic material and chert are generally absent from the sequence. The basalts are interbedded with varying amounts of green to gray, fine grained clastic sediments and tuffs, and these appear in drill core to make up the bulk of the succession in some areas.

The mafic volcanic sequence in this area is host to two volcanogenic Cu (+Zn) deposits, the Great Burnt Lake and South Pond deposits, which are further discussed in a subsequent section.

Minor amounts of mafic volcanic rocks are interbedded with tuffs and arkoses of Unit 11 near the North Salmon River north of Round Pond. These consist of very sheared, green, tuffaceous-looking rocks which outcrop sporadically along the river banks. They are correlated with similar small lenses mapped by Colman-Sadd (1980) in the North Steady Pond Formation to the east.

Basalts of Unit 15 cannot, on outcrop inspection, be distinguished from the mafic volcanic rocks which cap the Pipestone Pond complex. The distinction is presently made on the basis of associated lithologies and position in the stratigraphic succession which suggests that Unit 15 basalts formed during a period of island arc volcanism. It seems likely, based on these criteria, that the extensive mafic volcanic belt in the Baie d'Espoir Group is different from and younger than the ophiolitic rocks exposed along the North Salmon River and Jamieson Hills. This correlation is not as certain for small lenses of mafic volcanic rocks within the Baie d'Espoir Group sequence such as those east of the North Salmon Dam and northwest of Godaleich Pond, which could as easily represent fragments of ophiolitic rocks introduced along faults. Whole rock geochemical studies are in progress which will be directed towards resolving the differences between and distribution of the two episodes of basaltic volcanism.

The Baie d'Espoir Group in the Great Burnt Lake area has been regionally metamorphosed in the greenschist facies and carries evidence of at least two deformations. The first and main deformation formed upright, isoclinal folds and an associated penetrative axial planar cleavage which is uniformly present throughout the sequence. This cleavage commonly trends northeasterly to easterly with steep dips and is subparallel to bedding in most exposures. F_1 folds are rarely observed in the field but where seen, commonly have an amplitude of 0.5 to 1 m

and are sheared out along the limbs. A second deformation of variable intensity is occasionally recognized. In the area north of the North Salmon River and west of Pipestone Pond, the first cleavage is folded around moderately open, asymmetric folds with steep eastern limbs, the axes of which are approximately parallel to those of the F_1 folds. In the southern and eastern parts of the area, however, the second deformation is represented by a steep crenulation cleavage developed in the fine grained sedimentary rocks which trends north to northwest. No folds associated with this cleavage were recognized.

QUARTZITE, MATURE GRAYWACKE AND SHALE (UNIT 16)

Unit 16 underlies the eastern part of the map area. It consists dominantly of cream to white weathering quartzite and mature graywacke which forms blocky beds from 2 to 10 cm thick. The sandstones are commonly, although not always, interbedded with gray, fine grained clastic sediments. Fine laminations, scouring and channel fill are seen locally in well washed stream exposures south of Sitdown Pond.

This unit is the westward equivalent of rocks mapped in the adjacent map area by Colman-Sadd (1981). He noted a progressive low pressure metamorphism in these rocks towards two centers which culminated in the formation of banded gneiss and migmatite. The rocks of Unit 16 form the westward edge of the metamorphic aureole related to the Through Hill metamorphic center (Colman-Sadd, 1981). Exposures in the west near the Pipestone Pond Complex are metamorphosed in the greenschist facies but towards the east, show the progressive development of porphyroblasts of staurolite and andalusite in the more pelitic members. Some of these exposures are quite spectacular with up to 40% large andalusite porphyroblasts ranging up to 2 cm in size.

The age of Unit 16 is considered to be Lower-Middle Ordovician (uppermost Arenig to Lower Caradoc) on the basis of shelly fossils yielded by equivalent strata in the Miguels Lake map area (Colman-Sadd and Russell, 1982). It is lithologically similar to rocks of the Gander Group which is generally considered to be Middle Ordovician or earlier (e.g. Blackwood, 1981).

The principal deformation in Unit 16 is represented by a steep, penetrative cleavage which strikes generally north to northeast in the area of Sitdown Pond and east/southeast south and east of Sitdown Pond. This cleavage appears to be related to tight folds whose axes are steep and plunging to the south in the area west of Sitdown Pond. A later deformation is suggested by local changes in attitudes of the cleavage but it does not appear to have formed a penetrative fabric.

DEFORMED BIOTITE (+HORNBLÉNDE) GRANO-DIORITE (UNIT 17)

Deformed granitoid rocks of Unit 17 underlie most of the igneous/metamorphic terrain west of the Baie d'Espoir Group to the limits of the present mapping. The dominant lithology is strongly deformed, medium to very coarse grained, biotite (+hornblende) granodiorite which is usually quartz-poor but locally contains up to 10% bluish quartz eyes. The deformed granitoid rocks are locally gneissic and show a variable development of feldspar porphyroblasts ranging in size from 5 mm to 4 cm. Intensely flattened inclusions of schist and paragneiss, probably from Unit 8, are present in some exposures but there is no evidence that the granitoids have intruded the greenschist facies Baie d'Espoir Group in this area. The eastern contact with the Baie d'Espoir Group is marked by intense shearing and the local presence of sheared serpentinite, characteristic of most major faults in the area.

EQUIGRANULAR BIOTITE (+MUSCOVITE) GRANITE

Undeformed equigranular granite outcrops at a few localities in the present map area. One outcrop on the southeastern shore of Great Burnt Lake consists of medium grained biotite granite or granodiorite; however, this lithology makes up more than 50% of boulders along the lake shore and it seems likely that it is widely developed to the west of the present mapping. Many boulders of this rock type also contain minor muscovite and the rocks appear very similar to those which comprise the southeastern margin of the North Bay Granite in Bay d'Espoir (Colman-Sadd, 1976).

Along the western shore of the unnamed lake immediately north of Cold Spring Pond, there are several outcrops of equigranular, pink biotite ±(muscovite) granite (Unit 18) which appears to be a very late phase. It consists mainly of pink feldspar (70%) with 20% gray cloudy quartz and 10% platy biotite. No contact relations were observed and the full extent of this body is not known as it lies at the extreme western limit of mapping.

Isolated outcrops of muscovite and garnet bearing pegmatite are present in sediments of Unit 16 in the northeastern part of the map area. These are similar to and probably related to pegmatitic phases of the Through Hill Granite on the adjacent Burnt Hill map area (Colman-Sadd, 1981).

MINERALIZATION AND MINERAL EXPLORATION POTENTIAL

(1) Pipestone Pond Complex:

The first reported concentrations of economic minerals in the Great Burnt Lake area are hosted by the Pipestone Pond complex, these being the chromite occurrences east of Pipestone Pond. These prospects have previously been

examined and described in some detail by Snelgrove (1934), Fogwill (1964) and Kean (1974). Chromite is a ubiquitous constituent of the peridotites of Unit 1 throughout the Pipestone Pond complex where it is commonly widely disseminated, forming less than 0.5% of the rocks. However, in rare instances such as the Chrome Pond area, it is concentrated in pods which are generally less than 2 m but which may reach up to 6 m in length. The largest concentration noted during the present mapping is the Chrome Pond Prospect, a single pod approximately 6 m long and averaging 0.5 to 1 m wide hosted by sheared and serpentinized peridotite of Unit 1a. The showing occurs at the north end of a 100 m long outcrop ridge which displays unusual chromite concentration along its complete length. Several smaller pods up to 1 m in length are to be found in the immediate vicinity of the main showing. As well, blebs of massive chromite and zones of heavily disseminated chromite are common. Analyses of chromite from this area by Fogwill (1964) suggest that the material has a ratio Cr:Fe in the range 2.5 to 3.5; thus, if a deposit of mineable size could be outlined, there is every likelihood that the ore would produce a very high quality product.

Mapping throughout the ultramafic members of the ophiolite suggests that several other areas of slightly elevated chromite concentrations are present; none are known to be of economic proportions at the present time.

The sheared serpentinite of Unit 1a and Unit 2 is also host to minor occurrences of asbestos and magnesite. Asbestos generally occurs as very local concentrations of cross and slip fibre on widely spaced fracture surfaces. Exploration for magnesite has not been pursued in the Pipestone Pond complex with the same intensity as elsewhere in the eastern Newfoundland ultrabasic rocks (see review in Colman-Sadd and Swinden, 1981). The present mapping suggests that development of magnesite is not as widespread in this area as,

for example, in the Coy Pond and Great Bend areas. However, local concentrations are present, especially in Unit 1a in the vicinity of Chrome Pond, and further exploration would seem to be warranted.

The recognition of the Pipestone Pond complex as an ophiolite raises the possibility that depositional environments of ophiolitic massive sulfide deposits (Cyprus-type) may have been extant. The only pillow lavas considered on field evidence to be ophiolitic are those which underlie the western Jamieson Hills and the contact between the underlying gabbro/diabase and the volcanics appears to be exposed in this area. This environment, near the stratigraphic base of the pillow lavas is regarded as the most likely site of massive sulfide deposition, if such deposition did take place. No evidence of exhalative processes such as extensive alteration, exhalative iron or manganese rich horizons or sulfide concentrations were recognized during the present mapping. However, the basal part of the pillow lava unit would appear to be a good exploration target which, to the author's knowledge, is relatively untested.

(2) Baie d'Espoir Group

The Baie d'Espoir Group is considered to have the highest economic potential in the Great Burnt Lake area, both by virtue of the massive sulfide deposits known to be present in this unit and by virtue of apparently favourable environments developed elsewhere in the sequence.

Mafic volcanic rocks of the Baie d'Espoir Group (Unit 15) are host to two sulfide deposits east and northeast of Great Burnt Lake. The larger of these, the Great Burnt Lake deposit, is located on the southeast side of a prominent hill approximately 2 km northeast of the North Salmon Dam; the smaller deposit, the South Pond deposit, is located approximately 10 km to the north of the former deposit and approximately 3 km

southwest of South Pond. Both prospects are presently within the boundaries of a mining lease held by Abitibi-Price Inc. and Asarco Ltd. The sulfide zones are exposed; however, both have been extensively drilled and the following descriptions are based on examination of drill core from several holes which cut the deposits.

The Great Burnt Lake deposit is a roughly tabular, conformable body of massive pyrrhotite-chalcopyrite mineralization. The geologic sequence in the vicinity of the deposit consists of mafic flows and tuffs with interbedded siltstone and graywacke and fine grained clastic sediments which are locally graphitic. The deposit ranges up to 14 m in thickness, strikes approximately 030° , with steep dips to the southeast, and plunges gently to the southwest. The main mineralized zone carries sulfide concentrations ranging from less than 40% to 90%. Pyrrhotite is the dominant sulfide mineral present and occurs generally as massive beds. Chalcopyrite is distributed throughout the mineralized zone, forming large blebs within the massive pyrrhotite as well as discrete strata of massive mineralization up to 6 cm thick. To the west, the sulfide zone is in sharp contact with quartzose graywacke and siltstone; the sequence west of the mineralized zone shows little evidence of alteration and/or mineralization. To the east, the deposit is in contact with pillow lavas, although a mafic volcanic breccia up to 1.5 m thick is locally developed between the volcanics and the massive mineralization. The volcanic sequence to the east of the massive mineralization exhibits widespread although not particularly intense, alteration within 30 to 40 m of the massive zone. Black chloritization with associated stringers of pyrite, pyrrhotite and chalcopyrite and local silicification is the principal alteration effect. Similar alteration and sparse, erratic mineralization is prevalent in an apparently separate diffuse zone up to 335 m long and up to 75 m thick immediately north

and east of the massive zone. The geologic situation is suggestive of syngenetic sulfide mineralization on the sea floor at the top of a pillow lava succession and followed by a period of clastic sedimentation. The extensive alteration and sparse mineralization in rocks on the eastern side of the massive sulfide body may record the passage of hydrothermal fluids related to the mineralizing event and therefore suggest that the deposit is slightly overturned and facing to the northwest.

The Great Burnt Lake deposit is subeconomic at present. Recent estimates suggest that it contains on the order of 750,000 tonnes of 2-3% copper.

The South Pond deposit lies approximately 10 km north of the Great Burnt Lake deposit and occupies approximately the same stratigraphic interval. The geologic succession in this area is similar to that in the south, comprising pillow lava, mafic tuff and fine to medium grained clastic sediments. Sulfides are more widespread stratigraphically in this area and are present virtually throughout some drill cores. Pyrrhotite commonly comprises 0.5 to 1% in tuffaceous rocks and up to 20% over short sections. Chalcopyrite disseminations and blebs locally accompany the pyrrhotite and a particularly chalcopyrite-rich zone has been outlined which constitutes the South Pond deposit. This zone consists of up to 15 m of mafic tuff which contains up to 30% sulfides, consisting of pyrrhotite which forms anastomosing layers and semi-massive zones and disseminations and blebs up to 1 cm in diameter of chalcopyrite. The boundaries of the zone are gradational and reflect both a decrease in total sulfide content and an attendant disappearance of chalcopyrite.

The South Pond deposit is considerably smaller than the Great Burnt Lake prospect. It is estimated to contain in the order of 300,000 tonnes grading approximately 1% copper.

Although neither of these deposits is of economic size or grade, they are important indicators that exhalative processes accompanied this volcanism. Furthermore, mineralization is not restricted to the two known deposits in the volcanic belt; minor amounts of pyrrhotite and chalcopyrite have been noted in drill core between the two deposits and as well, new exposures recently uncovered near the North Salmon Dam are intensely chloritized and contain minor disseminated chalcopyrite. This new occurrence appears to be at the same stratigraphic level as the Great Burnt Lake prospect 2 km to the north. It appears from the present mapping that sulfide mineralization may have been widespread at this stratigraphic interval and the whole strike extension of the volcanic belt can be considered as favourable prospecting territory. It may be further noted that mafic volcanic rocks of the Baie d'Espoir Group outcrop in small belts northwest of Pipestone Pond and north of Round Pond. It is not known whether these basalts are strict stratigraphic equivalents of the mineralized sequence to the west; however, if they are so, they should also present favourable prospecting targets.

In addition to the potential for basalt-hosted cupriferous massive sulfides, there would also appear to be a good potential in the Baie d'Espoir Group for the discovery of volcanogenic sulfides associated with felsic volcanism. The principal target area is in and around Unit 14, the felsic volcanic unit which forms an east/west trending belt across the southeastern part of the area (the "Huxters Pond volcanics"). The felsic sequence consists primarily of rhyolitic to dacitic flows and ash flows which locally contain coarse breccias and agglomerates suggestive of nearby explosive volcanism. Although some exposures of the volcanic rocks show evidence of being deposited in subaerial conditions, the volcanics are interbedded with fine grained clastic

sediments suggestive of marine conditions and are part of a succession that includes turbidites and pillowed basalts. It seems likely, therefore, that they may have formed as, for example, volcanic islands. As such they present a highly favourable environment for massive sulfide deposits resulting from submarine fumarolic activity.

Massive sulfide deposition is known from similar environments elsewhere in southern Newfoundland. The Strickland Prospect and several associated occurrences in the La Poile Bay area of southwestern Newfoundland (Cooper, 1954; Stackhouse, 1976; Swinden, 1981a) occur in a volcano-sedimentary succession, the volcanic component of which is dominated by felsic rocks. Likewise, the Barasway de Cerf Prospect in southern Bay d'Espoir (Jewell, 1939; Swinden, 1980), although in a relatively basinal environment, is closely associated with pulses of felsic volcanism (Swinden, 1980). Massive sulfide mineralization associated with felsic volcanism in southern Newfoundland is dominantly Pb-Zn-Ag rich, with lesser pyrite and copper. By analogy, it might be expected that mineralization associated with the Huxters Pond volcanics would have a similar mineralogical composition; this could have implications for the exploration methods most likely to be successful in this terrain. Recognition of the felsic volcanic sequence in this part of Newfoundland is relatively recent (Colman-Sadd, 1981) and as a result, comparatively little exploration has been carried out. These felsic volcanics are accordingly considered to have a high potential for the discovery of volcanogenic mineralization.

The economic potential of the rest of the Baie d'Espoir Group is relatively unknown. Felsic volcanic rocks appear to be more widespread than was previously known; there is a distinct possibility that they host as yet undiscovered sulfide depositional environments. This is particularly true for the felsic pyroclastic rocks of Unit 13. Further

exploration is needed to better define the potential of these rocks.

(3) Western Igneous/Metamorphic Terrain

The economic potential of the igneous/metamorphic terrain to the west of the Baie d'Espoir Group is not well known. This terrain was not investigated in detail during the present program and a detailed economic assessment is therefore beyond the scope of this report. However, a few brief comments are justified.

The metamorphic rocks in this area appear to be dominantly metasediments and bear no obvious economic potential. However, northwest of Cold Spring Pond, they include some buff to white, very silicic rocks which appear to be metamorphosed felsic volcanics similar to those which form part of the Isle Galet Formation to the east (*e.g.* Colman-Sadd and Swinden, 1981). These were only seen in a few outcrops and their distribution is not known; however, they may present a favourable target for massive sulfide exploration.

Most of the granitoid rocks which outcrop within the present map area are highly deformed biotite (+hornblende) varieties which do not display any obvious potential. However, a late, undeformed pink biotite granite outcrops along the northwest shore of the unnamed lake immediately north of Cold Spring Pond. This may suggest that, as one progresses westward, perhaps more late granite plugs associated with the south-central Newfoundland granitoid complex will be encountered. This possibility is supported by the abundance of undeformed biotite and biotite-muscovite boulders along the eastern shore of Great Burnt Lake. It seems possible that a granitoid terrain which may be favourable for tin, tungsten, uranium and/or other lithophile elements similar to that at Granite Lake 30 km to the west (Dickson and MacLellan, 1981) may be present immediately west of the present map area. Further mapping in this area is needed to evaluate this possibility.

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COAL ASSESSMENT IN THE DEER LAKE CARBONIFEROUS BASIN

by

Ambrose Howse and James Fleischmann

An assessment of coal occurrences in the Deer Lake Carboniferous Basin was begun in the 1981 field season. The area examined lies within a narrow (approximately 1.2 km wide) sedimentary belt along the northeast shore of Grand lake. The belt extends from Hinds Brook in the southwest to Kelvin Brook in the northeast, a distance of about 11 km, and comprises a series of sedimentary units known as the Howley Beds. Hacquebard *et al.* (1960) determined the Howley Beds, from spore dating, to be Westphalian A age, thus correlating the coal-bearing strata in terms of age, with the late Cansoan or early Riversdalian strata of the Maritime Provinces.

The existence of coal in the Howley area was first noted by Newfoundland's first government geologist, J.B. Jukes, in 1839-40. He reported a 15 cm coal seam on Coal Brook (Snelgrove, 1953). Additional coal occurrences on Coal, Alder and Kelvin Brooks and in the Goose Brook area, were reported by Howley (1893, 1913), who made a prodigious but unsuccessful effort to locate a coal field. A coal seam on Coal Brook was exploited on a small scale by the Reid Newfoundland Development Company in 1914, and later further explored underground by the Anglo-Newfoundland Development Company (1947). Hayes' (1949) survey of Newfoundland coal occurrences concentrated mainly on coal occurrences in the St. George Carboniferous basin with apparently minimal field work in the Howley area. For a more comprehensive treatment of the history of coal exploration in the Howley area, readers are referred to an unpublished report by Hyde (1978).

Analytical data listed by Hayes (1949) for 10 samples of Howley coal and vitrinite reflectance values obtained by

Hacquebard and Donaldson (1970) from four samples indicate that it has a high volatile B rank.

The 1981 field project consisted of detailed mapping along 5 streams (Kelvin, Coal, Alder and two small unnamed streams). Except for certain sections of Coal and Alder Brooks, bedrock exposure is generally poor and greatly restricts geological interpretation.

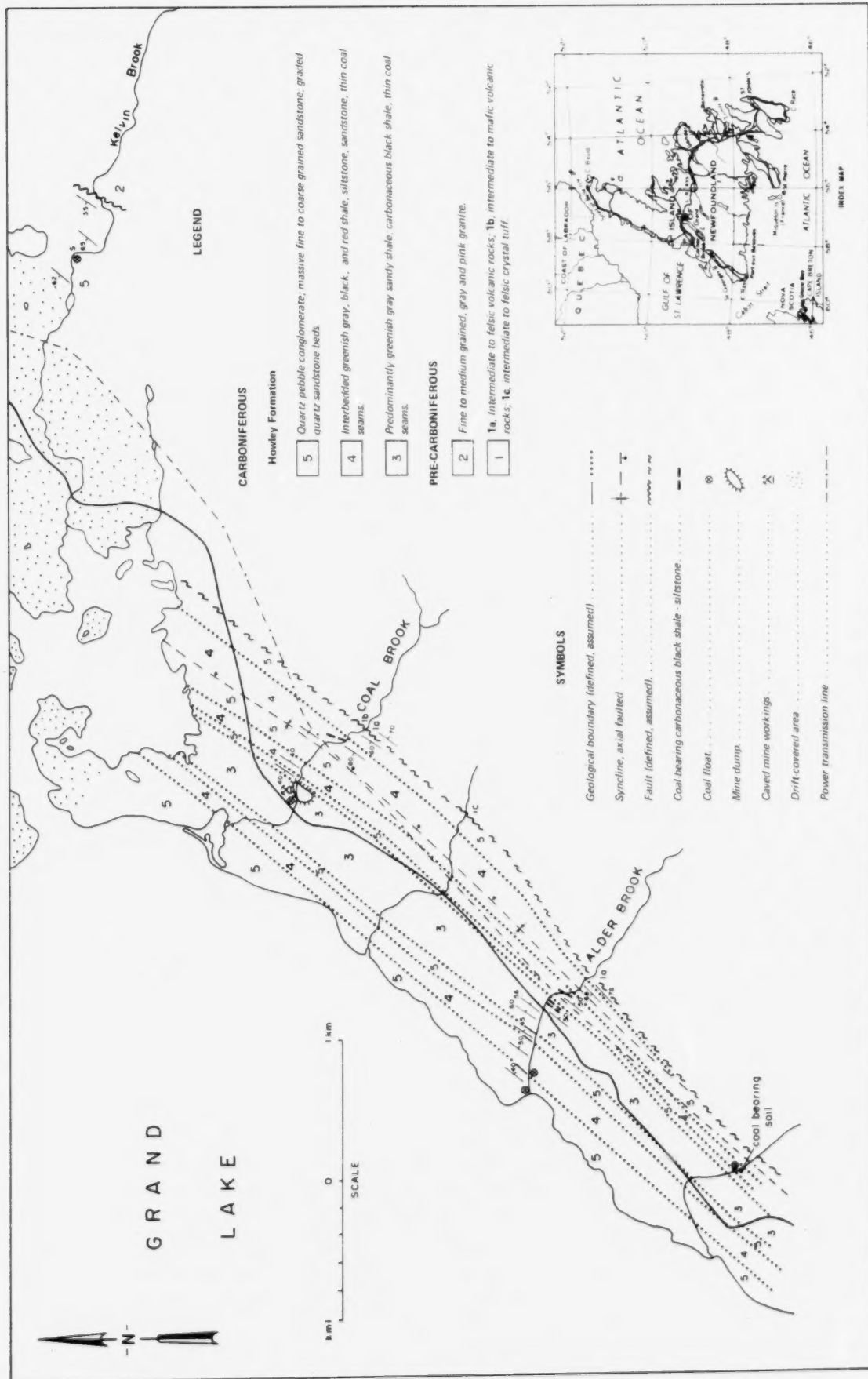
Some geophysical surveys (ground VLF-EM and magnetic) were also carried out.

GEOLOGY

Rocks of the area were divided into 5 main units. Volcanic rocks (Unit 1) and granite (Unit 2) constitute the Pre-Carboniferous eastern boundary of the Howley Beds. Predominantly greenish gray, sandy shale, carbonaceous black shale with thin coal seams (Unit 3), interbedded greenish gray, black, red shale, siltstone, sandstone and thin coal seams (Unit 4), and quartz pebble conglomerate, massive fine to coarse grained sandstone, and graded quartz sandstone beds (Unit 5) comprise the Howley Beds. The sedimentary rocks form a long northeast striking synclinal structure. A high-angle fault is postulated to lie along the fold's axis. This could explain the contrasting rock types which lie adjacent to the proposed axis.

UNIT 1

Volcanic rocks define the eastern boundary of the Howley Beds with which they are in fault contact. No attempt was made to divide these rocks beyond the immediate contact area, however, intermediate to felsic rocks were



observed on Coal Brook and Alder Brook, intermediate to mafic rocks on Coal Brook and intermediate-felsic crystal tuff on the innamed brook that flows roughly midway between and parallel to Coal and Alder Brooks.

UNIT 2

Highly sheared and altered fine to medium grained gray and pink granite was noted on Kelvin Brook where it forms the eastern boundary of the Howley Beds at that point.

UNIT 3

Greenish-gray sandy shale with minor carbonaceous shale form a belt of northeast striking southeasterly dipping rocks noted mainly on Alder and Coal Brooks. Rusty weathered sandy shale with up to 5% fine grained muscovite and chloritic sandy shale occur in the stream bed on Coal Brook near the old coal mine dump. Several thin beds of carbonaceous shale containing very thin coal seams were identified in this unit on Alder Brook, and although no *in situ* coal was found in the equivalent rocks on Coal Brook, the old mine dump contains numerous fragments of coal, which are strong evidence that such seams exist, but are probably obscured by overburden and dump material.

UNIT 4

Unit 4 consists of interbedded greenish-gray, black and red shale and siltstone, quartz sandstone and minor thin coal seams. The best exposed section of this unit occurs in the bed of Coal Brook about 800 m upstream from the hydro road bridge. There, a 50 m cross-section of steeply westward dipping strata is exposed. Twelve beds were identified in this section and are described below in ascending order:

0-3.0 m Sandstone, grades from fine to coarse grained (fining upwards). Five percent quartz feldspar pebbles, which average 2 mm in

diameter in a gray, coarse sandy matrix grades upwards into fine grained gray sandstone.

3.0-5.5 m Quartz sandstone, light gray, medium grained, micaceous. Contains plant debris (stems, twigs, etc.)

5.5-9.5 m Shale, rusty weathered surface, greenish-gray fresh surface, micaceous, moderately fissile.

9.5-16.0 m Siltstone, rusty weathered surface, dark gray to black fresh surface, fine to very fine grained, massive, 2-3% sericite, ripple laminated.

16.0-18.5 m Shale, rusty weathered surface, black fresh surface, fine grained, contains abundant iron nodules concentrated in a 0.5 m wide basal zone.

18.5-19.0 m Sandstone, light brown to buff weathered surface, light gray fresh surface, fine grained, joints perpendicular to bedding filled with quartz carbonate.

19.0-19.7 m Shale, rusty weathered surface, dark gray fresh surface, fine grained, 10-15% sericite, ironstones up to 8 cm in diameter present.

19.7-20.0 m Shale, red, fine grained.

20.0-24.5 m Shale, dark gray to black, mottled, fine grained, contains numerous, randomly distributed, conical to cylindrically shaped ironstone nodules up to 6 cm (long axis), 3 cm (short axis).

24.5-25.3 m Coal, highly weathered, mixed with carbonaceous shale.

25.3-33.0 m Shale, sandy, rusty weathering, fine grained, light gray, micaceous in part, crossbedded.

33.0-49.0 m Sandstone, light gray to buff, medium to coarse grained, abundant subrounded to angular quartz pebbles averaging 1 mm in diameter near top of bed.

The distinctive association of thin coal seams and ironstone bearing, mottled shales was also noted in equivalent rocks exposed along strike, a short distance upstream from the hydro access road bridge on Alder Brook. Also at this location, a 1 m wide bed of coalbearing shale occurs, underlain by massive fine grained, dark gray, micaceous sandstone containing carbonaceous films and rootlets.

Mottling, ferruginous nodules, carbon films and rootlets are all diagnostic features of ancient soils (Collinson, 1978). The mottled appearance is attributed to migration in solution of iron and manganese ions leading to the patchy accumulation of their oxides and hydroxides as grain coatings. The nodules are interpreted as being due to precipitation from groundwater. Ferruginous nodules are commonly associated with rootlet bearing gray beds below coal seams and in the Carboniferous coal measures these rootlets are usually preserved as carbon films. The coals are thought to be the product of *in situ* plant growth and decay with the seat earth (paleosol) being the soil for the earliest plants, the decomposition of which would provide a soil for later plants.

UNIT 5

Unit 5 consists of quartz-pebble conglomerate, massive, fine to coarse grained sandstone and graded quartz sandstone beds. Three isolated but spectacular outcrops of cobble-boulder conglomerate that occur on Kelvin Brook near the granite contact, have been included in Unit 5.

The quartz pebble conglomerate occurs in fairly massive to massive outcrops; pebbles of quartz are

prominent on the brown weathered surface. The fresh surface is light gray-brown. Rounded - subrounded - angular quartz pebbles up to 5 cm in diameter constitute 5-20% of the rock in a coarse grained sandy matrix usually containing about 5% medium grained muscovite. Although quartz pebbles dominate, feldspar clasts were also observed. The unit also contains light gray to buff, fine to coarse grained sandstone and graded quartz sandstone occurring in fining upward sequences. One particularly well exposed outcrop on Alder Brook consists of 8-10 graded beds averaging 1.7 m thick underlain by a basal quartz pebble conglomerate.

Three outcrops of cobble-boulder conglomerate were observed on Kelvin Brook near the contact with pre-Carboniferous rocks (granite). Two outcrops separated by a 2 m band of red mudstone occurs about 350 m downstream from the granite contact. The rock consists of 40% poorly sorted pebbles, cobbles and boulders comprising a wide variety of sizes, shapes and lithologies set in 60% matrix of greenish coarse grained sandstone. The pebbles and cobbles appear to be orientated parallel to the bedding and there is some suggestion of a coarsening upwards graded bedding. About 230 m upstream at least ten graded conglomeratic beds were identified each up to 50 cm thick and consisting of poorly sorted pebbles and cobbles in a red silty matrix.

COAL OCCURRENCES

Five coal-bearing carbonaceous shale units were identified, four of which occur in close proximity with each other along the west bank of Alder Brook. The thickest unit is about one metre wide and contains 30-40% thin (up to 2 cm) coal seams. Other such units may exist along the same slope, but mud, gravel and an almost impenetratable tangle of deadfalls cover the bedrock. Coal float, the largest of which measures 15 cm by 25 cm, is common in the stream bed in this area and is

probably derived from a thicker unexposed coal seam upstream.

The fifth coal bearing unit, a 0.8 m wide carbonaceous shale unit located about 800 m upstream from the hydro road along coal Brook, contains <10% thin coal seams. The association of these coal-bearing horizons with underlying shales and sandy shales containing features characteristic of ancient soils has already been noted.

A coal-bearing soil occurs on an unnamed stream located about 1.8 km southwest of Alder Brook and is described with the soil profile below.

0 - 10 cm	organic layer
10 - 120 cm	rusty cobbly till
120 - 145 cm	grayish brown clayey silt
145 - 153 cm	dark gray silty clay
153 - 162 cm	black carbonaceous clayey silt with abundant minute coal chips (pinches out downstream)
162 - ?	brownish gray clayey silt

Coal chips from the soil have been sampled for analysis.

A one metre wide zone of dark carbonaceous soil containing coal chips was also discovered on Kelvin Brook about 2 km upstream from the hydro road. Due to the lack of outcrop and the weathered nature of the material, it is difficult to determine whether this represents a weathered shale-coal zone, or an unconsolidated soil containing coal chips.

Mine dumps, collapsed workings and trenched areas were identified over the abandoned mine on Coal Brook. No *in situ* coal seams were found and are perhaps masked by the heavy vegetation dump material which straddles the stream. Fragments of coal from the site were collected for analysis.

GEOPHYSICS

Ground VLF-EM and magnetic surveys (using a Geonics EM16 and Scintrex Fluxgate magnetometer) were conducted over the coal-bearing shale units that were identified. The surveys were also conducted over the old mine site on Coal Brook utilizing a grid consisting of a cut baseline and flagged crosslines (20 m spacing). The objective was to test the effectiveness of those types of surveys in delineating the geology. Both types of surveys proved to be ineffective. The particularly flat EM profiles recorded may be due to the thick multi-layered nature of the area's overburden which includes a ubiquitous layer of clay.

Scintillometer readings were recorded over most of the outcrop exposures. Carbonaceous rocks and soils characteristically yielded higher counts, 2-3 times background. The highest counts were recorded over coal-bearing shales (1400 cps).

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COAL ASSESSMENT IN THE BAY ST. GEORGE CARBONIFEROUS BASIN

by

Ambrose Howse and James Fleischmann

INTRODUCTION

A field investigation of coal deposits of the Bay St. George Carboniferous Basin was carried out during the month of July and the first week of August, 1981. These deposits occur in the Barachois Group of sedimentary rocks which are the youngest rocks in the area. Coal seams occur along Middle Barachois Brook and in two small localities in the Codroy Valley near South Branch and Tompkins. It has been dated as Westphalian A (Utting, 1966) and is equivalent to the Riversdalian of the Maritime Provinces (Hacquebard *et al.*, 1960). The coal was graded as high volatile B bituminous and classed as lower rank, with between 47 to 70 percent free carbon, 3-24 percent ash and 1-8 percent sulphur (Hayes, 1949).

Periodic investigations of the Barachois Brook coal were carried out in the last century (Murray, 1873; Fletcher, 1874; Howley, 1897) and continued until the middle of this century (Dowling, 1920; Baker, 1927; Bryan, 1938; Hayes, 1949). The latter two assessments concluded that the coal seams which had been somewhat exaggerated in their thicknesses by the early reports, were in fact thin, impure, and discontinuous, and also greatly disturbed by folding and faulting. For a more detailed account of the above investigations and their results, readers are referred to the review of coal in the Bay St. George Basin by Knight (1979).

The 1981 field work concentrated mainly on the coal occurrences on Middle Barachois Brook. The project was aimed at obtaining a better definition of the location, size, quality and geological setting of the coal seams.

Detailed (1:1,000) geological mapping was carried out and coal seams were sampled. Some VLF-EM lines were run as a supplement to the mapping, mainly to trace faults. Scintillometer readings were recorded over outcrops and coal seams.

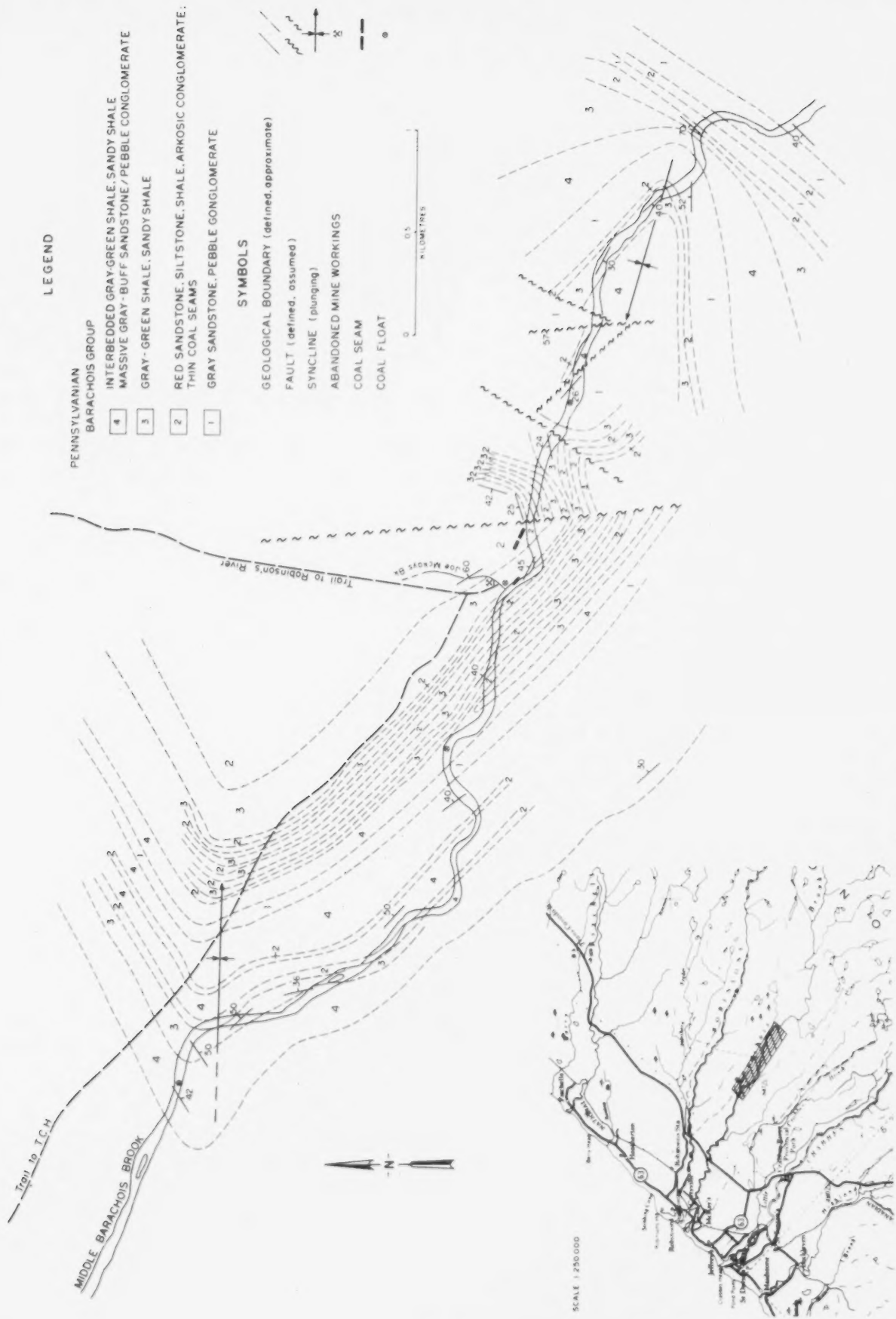
GEOLOGY

Repetitive sedimentary lithologies occur along Middle Barachois Brook. They consist of gray sandstone and pebble conglomerate (1), red sandstone, siltstone, shale and arkosic conglomerate (2), gray-green shale, sandy shale (3) and interbedded gray-green shale and massive gray-buff sandstone/pebble conglomerate (4). The beds dip steeply and define a curving basin-like structure interpreted to be a doubly plunging syncline. Coal seams are associated with the uppermost strata in the syncline.

The strata are complexly folded and faulted as evidenced by the variance in bed attitude and the shattered nature of some outcrops, particularly in the area immediately west of Joe McKay's Brook. A major fault is postulated to run in an approximate north-south direction about 500 m east of Joe McKay's Brook. Although its existence was first based on geological data, geophysical evidence was provided by a VLF-EM profile, run normal to the fault's projected strike. The line, located about one kilometre north of the brook, detected a conductive zone believed to be caused by water-filled shears associated with the fault.

UNIT 1

This unit, consisting of gray sandstone and pebble conglomerate, was observed most frequently in the stream



bed beginning at a point about one kilometre east of the mouth of Joe McKay's Brook. This is a structurally complex area where the bedding has been greatly fragmented by faulting. The unit was observed in fault contact with shales and sandstone of Unit 4 in two locations. Along the eastern part of the mapped area, it appears to form a cyclic pattern with shale and sandy shale of Unit 2. The unit is typically massive and well bedded. Fossil plants are common with plant stems up to 20 cm in diameter observed.

UNIT 2

This unit consists of red sandstone, siltstone, shale and arkosic conglomerate and occurs throughout the mapped area, but becomes particularly prominent towards the centre of the basin where red sandstones, siltstones and shales form a cyclic repetitive pattern with the green shale and siltstone of Unit 3. These rocks are especially significant in that coal has been identified with them. On the north bank of Middle Barachois Brook, about 320 m upstream from the mouth of Joe McKay's Brook, an exposed section shows a 0.5 m thick coal seam capped by a 4 m band of carbonaceous black shale and overlain and underlain by red shale and sandstone beds averaging 1.3 m thickness. The red sandstone bed immediately underlying the coal contains abundant fossil plants and impressions.

Crossbedding both on a micro and macro scale was observed in several outcrops of red sandstone and shale. In one outcrop of red sandstone, the crossbedding is accentuated by very thin, light gray sandstone laminations. Another outcrop of fine to very fine grained red shale near the mouth of Joe McKay's Brook displays small scale crossbedding indicating paleocurrent from the south.

UNIT 3

Gray-green shales and sandy shales

of Unit 3 appear to form a cyclic pattern with the red sandstone, siltstone and shales and this feature becomes more apparent towards the centre of the basin. One outcrop of fine grained, greenish-gray shale contains cobble-size dropstones indicating tops upward. Fine grained greenish shale with abundant hematite streaks and laminations was also observed. Well defined mud cracks were noted in a large exposure of massive fine grained greenish-gray sandy shale. Ripple marks indicating a paleocurrent from south to north were also noted in an outcrop of greenish gray shale.

UNIT 4

Relatively wide zones of interbedded gray-green shale, sandy shale and massive gray-buff sandstone/pebble conglomerate occur throughout the map area. In one typical outcrop, the beds average 1 m thick and consist of massive, fine grained gray sandstone overlain by gray shale and greenish-gray sandy shale overlain by coarse grained, buff-colored pebble conglomerate. The latter consists of 10-20% subrounded quartz-feldspar pebbles averaging 1-3 cm in a fine to medium grained greenish sandy matrix. Fining upward textures were observed in some of the sandstone beds.

Unit 4 also includes mottled, rusty clayey siltstone beds bearing carbonate nodules. In one outcrop, 10 such beds were noted, separated by highly weathered, dark gray-black shaly mudstone. About 3.2 km west of Joe McKay's Brook and on the south bank of the brook, interbedded highly weathered carbonaceous black shales (1-10 cm thick) and fine to very fine grained light gray sandstone beds (10-30 cm thick) are underlain by mottled greenish gray nodular shale. Small weathered out fragments of coal were found associated with the carbonaceous shale. These fragments have been sampled for analysis.

In some of the gray sandstones, fossil plants are fairly common usually in the form of tree fragments and bark. Well preserved ripple marks and mudcracks are also present especially in outcrops which have undergone fracturing along bedding planes so that relatively fresh unweathered surfaces have been exposed by recent landslides.

COAL OCCURRENCES

The best exposed coal seam was observed on the north bank of Middle Barachois Brook about 230 m upstream from the mouth of Joe McKay's Brook. It consists of a 0.5 m wide seam of hard, bright coal overlain by 0.4 m of carbonaceous black shale and at least three beds of red shale and sandstone averaging 1.3 m in thickness. The coal seam is underlain by fine grained reddish sandstone with abundant plants and impressions which, in turn, is underlain by a 1.5 m bed of dark gray to black shale. A moderately massive, fine grained red sandstone is the lowest unit that can be identified in the section. The coal seams widen to about 0.7 m about 20 m along its northwest strike, thus suggesting a lenticular shape. There is also evidence that the seam grades into shale along its southeastern projection, although there the strata is obscured by overburden and faulting.

The section described above is obscured by broken bedrock and organic material near and at the top of the river bank. It is interesting to note that the broken rock includes, and in places is covered with, coal fragments. This strongly suggests the presence of another, stratigraphically higher coal seam, probably within 8 m (vertical distance) of the exposed seam.

A 30 cm weathered coal seam was located in the stream bed about 110 m east of the mouth of Joe McKay's Brook. The coal is underlain by massive fine grained sandstone and overlain by gray-black shale. The seam can be traced along its northwesterly strike for only

two or three metres and is visible only when the water level is low.

Weathered out coal chips were located associated with thin carbonaceous black shales about 3.2 m west of Joe McKay's Brook and have already been described earlier in this report.

No *in situ* coal was found amid the old mine dump and workings noted in the stream bed and on the west bank of Joe McKay's Brook.

GEOPHYSICS

The VLF-EM surveys, though ineffective in tracing coal seams, proved useful in helping to confirm the existence of a major fault which crosses Middle Barachois Brook immediately east of the coal seams. This fault was first shown by Hayes (1949) from geological data recorded in the stream bed. A VLF-EM line run normal to the faults projected strike about 800 m north of the brook detected a conductive zone believed to be caused by water-filled shears associated with the fault.

Scintillometer readings were recorded over most of the outcrops in the map area. Carbonaceous rocks and soils characteristically yield higher counts (2-3 times background). The highest reading (1800 cps) was recorded over a 30 cm band of highly weathered black carbonaceous clayey material. This band was underlain by weathered rusty, mottled, gray siltstone (paleosol) (900 cps) and overlain by thin bands of gray siltstones and shales (500-600 cps).

The coal seam in the stream bed near Joe McKays Brook gave a reading of 850 cps compared to a background of 750 cps for its host rocks.

ACKNOWLEDGEMENTS

We thank Paul Dean for his help, advice and encouragement, Ian Knight for his interest and advice, and the fishery officers on Middle Barachois Brook for

allowing us to occasionally share swimming facilities with the salmon in Mine Pool, plus other kindnesses.

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MEMORIAL AND DIMENSION STONE

by

S.L. Tomlin

INTRODUCTION

During the second season of a two year program to assess the dimension stone potential of Insular Newfoundland, the gabbros and granites of the Mount Peyton Batholith in Central Newfoundland were examined. The determination of the mafic gabbro's potential as a source of memorial stone (industry's 'black granite'), is the primary concern of this study. The rock was assessed for its color and textural qualities which must be in keeping with the high degree of aesthetic beauty needed for use in the monumental stone industry. Structural qualities were studied to see if sufficient size slabs are available to quarry. A minimum block size of 1.0 m x 1.2 m x 1.5 m is considered economic by most major stone operations.

LOCATION - ACCESS

The Mount Peyton Batholith is located in Central Newfoundland between the towns of Glenwood and Bishops Falls and is bounded on the south and east by the Northwest Gander River valley and on the west by the Rattling Brook valley. The northwestern section is bordered by the Trans Canada and Bay d'Espoir highways, to which are connected numerous logging roads offering good access. The remainder of the batholith, with the exception of Mount Peyton itself, is low lying, offering little exposure and is less accessible by road.

GEOLOGICAL HISTORY

The Mount Peyton Batholith is an elliptical intrusive complex which has an outcrop area of 30 x 60 km. The Devonian batholith has intruded volcanics and sediments of the Silurian Botwood and Ordovician Davidsville Groups.

The batholith consists of two main phases: (1) a dark green to black pyroxene gabbro and (2) a pink granite phase which intrudes the gabbro. The gabbro and granite are believed to have separate origins of derivation from the upper mantle and crustal anatexis, respectively, rather than a common origin due to fractionation (Strong, 1979).

FIELD WORK

The study concentrated on the northwestern section of the batholith, centred around Borney Lake and Rattling Lake, where outcrop is well exposed along a series of NE-SW striking ridges. After three weeks of mapping and traversing the area, five areas having the greatest potential were selected to be studied in further detail. The fracture patterns of the potential quarry sites were mapped in detail and samples from each area were collected for polishing and for thin sections. Several shallow holes were drilled with a packsack diamond drill to test the quality of the stone and the continuity of joint patterns at depth.

PRELIMINARY RESULTS

The following five areas of the Mount Peyton Batholith show some potential for the removal of large blocks of gabbro. The gabbro at these five locations are similar in structure and texture and differ mainly in the degree of jointing and weathering. There are also minor mineralogical differences.

(1) Black gabbro outcrops at five or six locations along the southeastern shore of Borney Lake. These outcrops are spread out over a half kilometre of shoreline.

The rock is massive and jointed. Two joint directions, one parallel (32°) and one perpendicular (112°) to the shoreline and fracturing, are the only structural features present. A 1 m joint interval is present in half the outcrop area, with at least one 2 m x 2 m joint free area in each outcrop.

The rock is black and fine grained with modal mineralogy as follows:

Plagioclase	50%
Pyroxene	40%
Quartz	7%
Opagues (Magnetite)	3%

(2) A small outcrop approximately 10 m x 10 m is exposed one kilometre north of Borney Lake, beside a logging road and less than one kilometre from a power line.

Few joints are present on surface or to a depth of 6.5 m. Surface joints strike 100° and 031° which are similar to the joint pattern of the outcrops beside Borney Lake. The rock is black, massive, fine grained (0.5 - 1.0 mm) and similar to the rocks at Borney Lake. Mineralogy is as follows:

Plagioclase	50%
Pyroxene	30%
Hornblende	15%
Opaque (Magnetite)	3%
Quartz	2%

(3) Gabbro outcrops on the north side of the Trans Canada Highway near Norris Arm and extends for 35 m. This rock is massive and although the jointing is regular and closely spaced, the degree of fracturing and jointing due to blasting is uncertain.

The gabbro is black and fine grained (0.5 to 1.0 mm) and consists mainly of plagioclase and pyroxene. This outcrop was studied as it is well exposed but should not be considered a potential quarry site due to the close proximity to the Trans Canada Highway.

(4) A large 60 x 20 m gabbro outcrop is located 200 m south of the Trans Canada Highway along the Rattling Brook, near Norris Arm.

The joint pattern is regular with a well developed joint set at 50° . Dips of 45° and 90° are associated with this joint direction. A second poorly developed joint set strikes perpendicular to the first.

The joint interval ranges from 1 m to 4 m for the well developed joint set and 4 to 8 m for the poorly developed set.

The rock is black, massive and fine grained. Quartz veinlets and stringers striking 50° appear to be associated with one joint direction. Mineralogy is as follows:

Plagioclase	50%
Pyroxene	25%
K-feldspar (white)	20%
Opaque (Magnetite)	5%

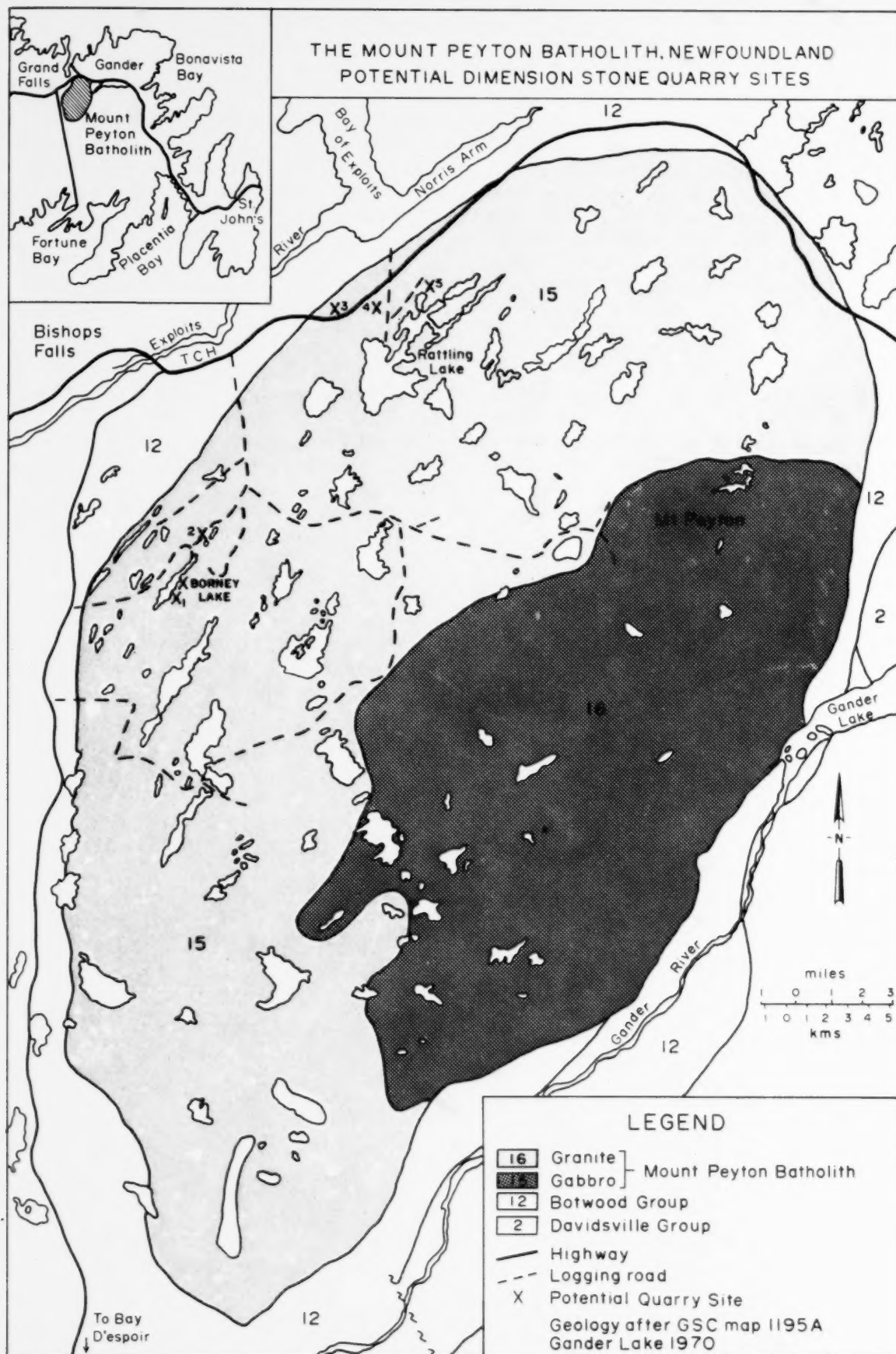
(5) An outcrop of massive and moderately well jointed gabbro is located on the northwestern shore of Amy's Lake. The joint interval is closely spaced in sections of the outcrop, but in other sections, the joints form sufficient sized blocks.

Small veinlets of leucogabbro occur within the dark gabbro, but these can be easily removed by trimming of the slabs after quarrying. The mineralogy is as follows:

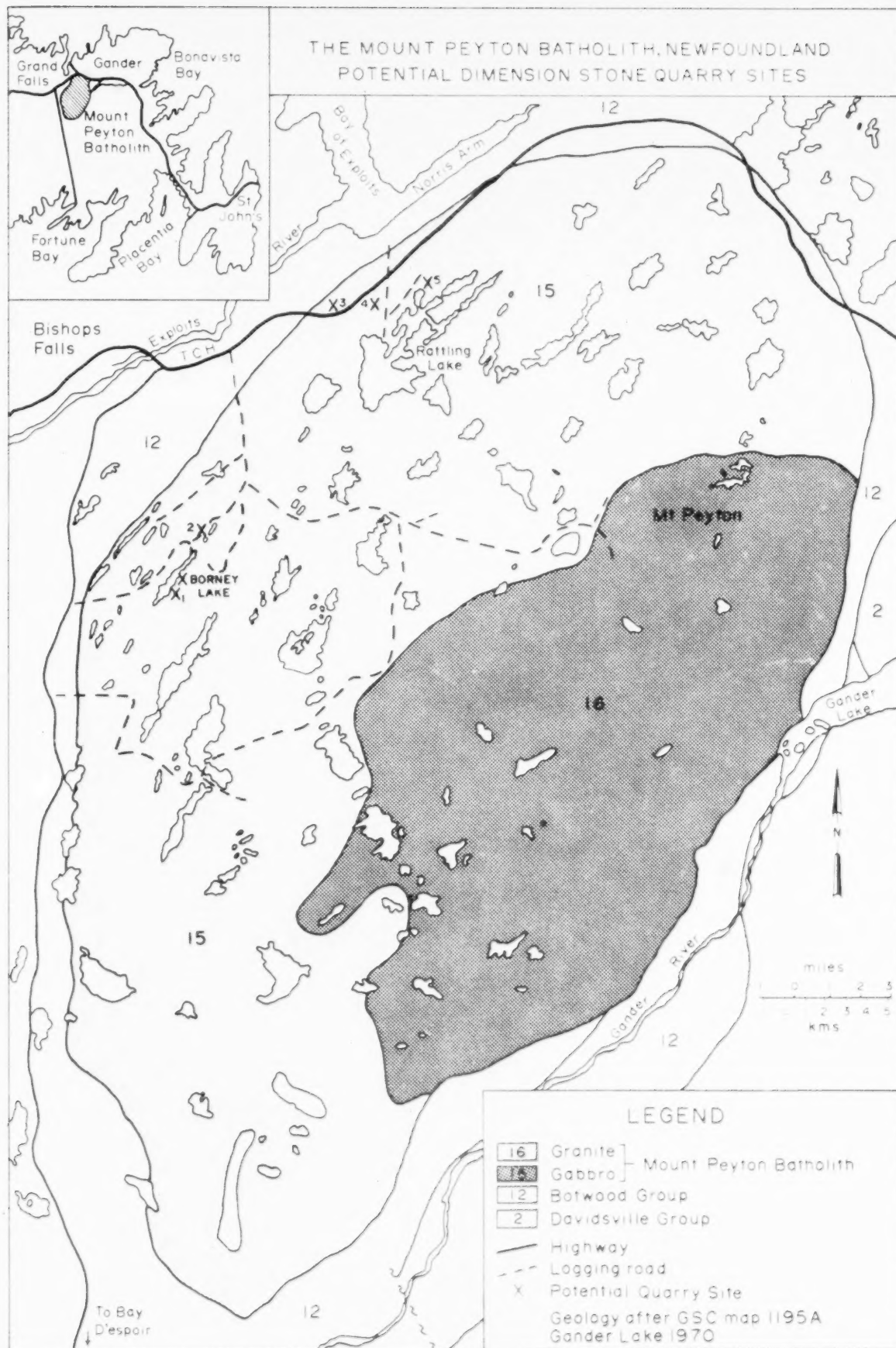
Plagioclase	50%
Pyroxene	30%
Hornblende	15%
Opaque (Magnetite)	5%

OTHER AREAS

Granite outcrops near Seal Cove on the Hermitage Peninsula. The rock is massive, even textured, medium grained and is a deep red colour. The joints are well spaced and form blocks larger than 4 m x 4 m.



THE MOUNT PEYTON BATHOLITH, NEWFOUNDLAND POTENTIAL DIMENSION STONE QUARRY SITES



The Grole Diorite outcrops in this area adjacent to the granite. This dark stone is highly desirable because of its colour and even fine grained texture. However, the rock is highly fractured and not suitable for memorial stone. This rock would make an excellent 'black granite' if suitable massive outcrops are discovered.

CONCLUSION

At this stage in the study, all areas mapped in detail show some potential as quarry sites for dimension and monumental stone. Further tests are

needed to determine the aesthetic properties of the stone after slabbing and polishing. Thin section studies will give additional mineralogical data to determine the degree of alteration of the pyroxene and feldspars.

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MINERAL OCCURRENCE DATA SYSTEM (MODS)

by

Harjit S. Missan

Information regarding the geology or history of exploration work on a mineral property is often required by many different users over a long period. The compilation of this data is further complicated by ever changing conditions such as mineral supply and demand, price, new exploration ideas and ownership changes. Mineral deposit data therefore, being voluminous, diverse and of recurrent and varied nature are natural candidates for computerization.

The Mineral Occurrence Data System (MODS) is a computer processable file containing information on the mineral occurrences of the Province. The major categories under which information is collected on the mineral occurrences are:

1. LOCATION
2. NAME AND OWNERSHIP
3. DESCRIPTION OF DEPOSIT
4. GEOLOGICAL SETTING
5. EXPLORATION AND DEVELOPMENT
6. BIBLIOGRAPHY

So far the following areas have been documented and the information on the mineral occurrences computerized:

INSULAR NEWFOUNDLAND

1. NTS 12B (Stephenville Sheet)

2. NTS 2E (Botwood Sheet)
3. NTS 12H (Sandy Lake Sheet)
4. NTS 12I (Port Saunders Sheet)
5. NTS 12P (Blanc-Sablon Sheet)
6. NTS 2L (Port Saunders Sheet)
7. NTS 2M (St. Anthony Sheet)

LABRADOR

1. NTS 13K (Seal Lake Sheet)
2. NTS 14C (Nain Sheet)

Presently, four areas are being worked on. They are:

1. The Central Mineral Belt (13J, 13O)
2. The Labrador Trough (23J, 23O)
3. Central Mobile Belt (12A)
4. The Avalon Zone (1N, 1K)

Mineral occurrence maps (1:250,000) have been produced for the following areas:

1. NTS 12B (Stephenville Map Sheet)
2. NTS 2E (Botwood Map Sheet)
3. NTS 14C (Nain Map Sheet)

Approximately 65% of the Province's mineral occurrences have been documented. It is planned to have the Province covered by March, 1983.

INVENTORY OF AGGREGATE RESOURCES

by

F.T. Kirby, R.J. Ricketts*, D.G. Vanderveer

INTRODUCTION

The 1980 sampling program marked the end of this reconnaissance level program which was begun in 1975. As a result of the completion of the sampling within the 6 km wide corridor study area, information on the aggregate resources is now available along all existing and proposed transportation routes in Newfoundland and Labrador (Maps 1 and 2).

The 1981 program was mainly office oriented, centered around the compilation of maps and sample data in a reproducible format, and the development of a computer package designed for easy search and retrieval of aggregate resource data. Minor field work was carried out in areas not previously sampled, and in areas where minor infilling was needed. Detailed aggregate assessments were carried out in two areas of the province where problems dealing with aggregate resources have arisen.

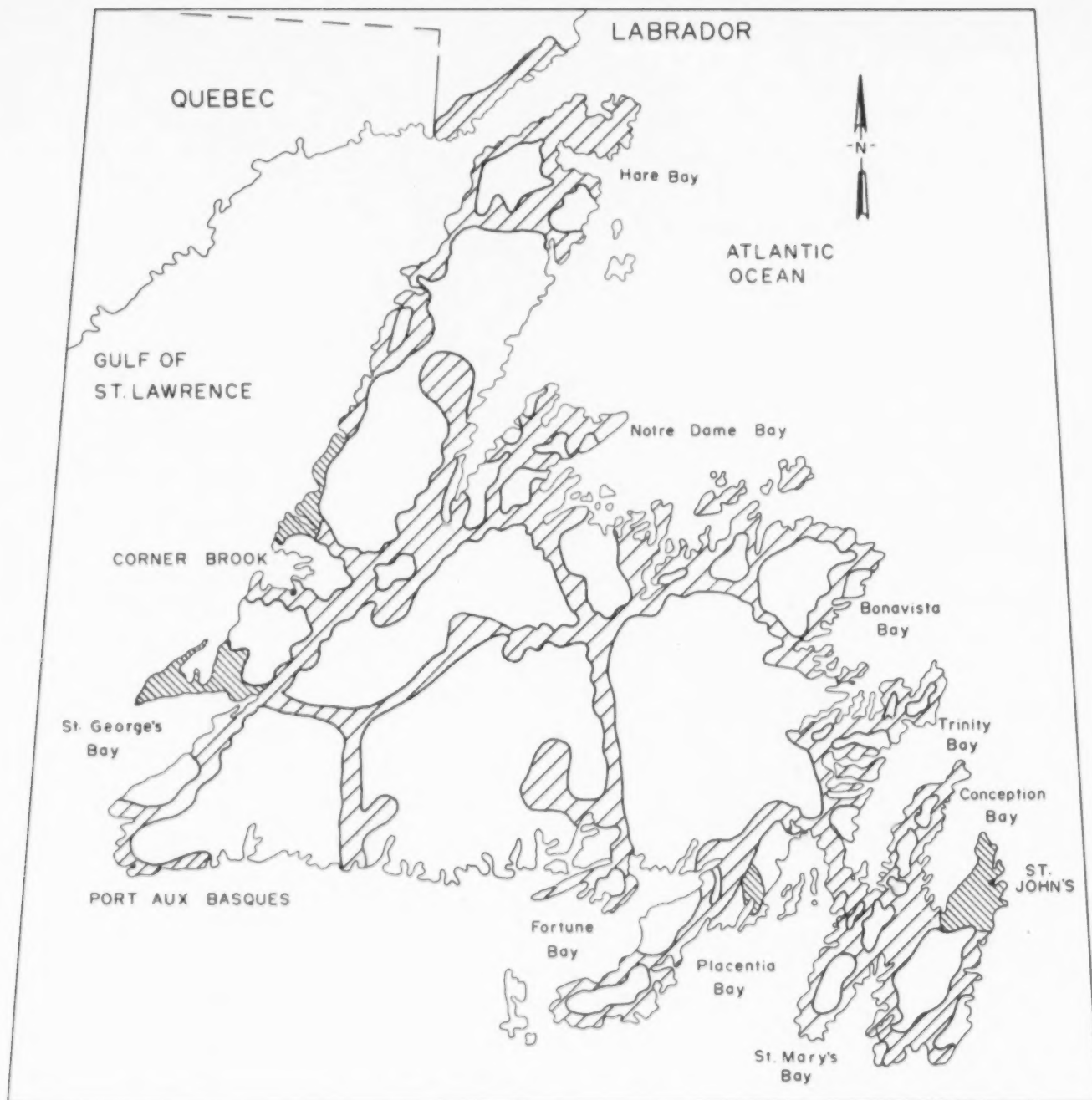
OFFICE PROGRAM

The majority of the work carried out in 1981 dealt with the compilation of the five different map series which are to be produced, plus associated reports and data compilation. The two sets of 1:50,000 scale maps consist of approximately 180 maps each. The first series of maps depicting sample localities and zones of aggregate potential are nearing completion. It is hoped that in the future, as time permits, we will be able to add quality and quantity information for each particular deposit indicated on these maps. The second series, the landform classification series, is about 60% complete, and it is hoped to have this series completed in 1982.

The 1:250,000 map series consists of three sets of approximately 30 maps each. The first series depicts sample locations. On this map series a summary of the sample locations are plotted by sample type. The second series is the zones of aggregate potential. These maps give a summary of the zones of aggregate potential as depicted on the 1:50,000 aggregate zones potential maps. The two 1:250,000 map series are presently being combined, and will be released as coloured maps plus report. These maps and reports will be released periodically as completed during 1982. The third 1:250,000 map series is the Geology series which gives a summary of the bedrock geology and will include marginal notes emphasizing the geotechnical properties of the rock type and their quarriability. It is hoped to release this map series by early 1982. A more detailed description of the different map series is being produced; the Information Report - Aggregate Resource Inventory of Newfoundland and Labrador will be released in early 1982.

Another major component in the office program has been the development and implementation of a computer package to handle the data that has been generated over the term of the project. The basis for the system is the SIR (Scientific Information and Retrieval) package. When the system is fully implemented, it will allow the easy search and retrieval of data on file, and to report this data in a format that is easily understood by the user. A more detailed description of the computer package will be included in the Information Report. The system is now undergoing final testing and implementation.

*Present Address: Department of Rural, Agriculture and Northern Development

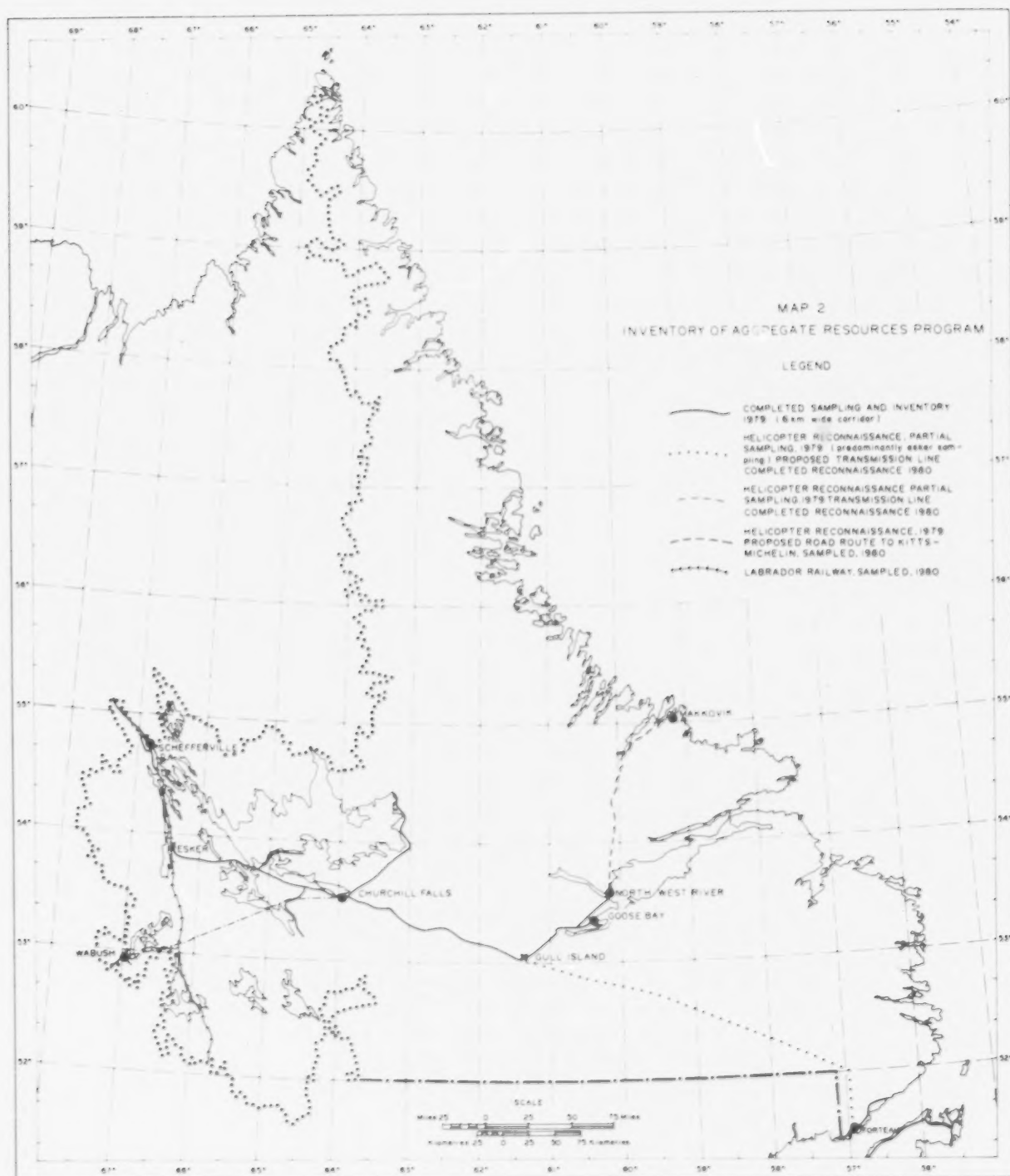


MAP 1

Inventory of Aggregate Resources Program
Island of Newfoundland
CANADA/NEWFOUNDLAND MINERAL DEVELOPMENT SUBSIDIARY AGREEMENT
SUBPROJECT 2.2

Legend

-  Completed 6 km wide corridor sampling parallel to existing roads and highways, and selected development areas.
-  1981 fieldwork including detailed assessments in previously sampled areas.
-  Unsurveyed areas, including Terra Nova National Park.



FIELD PROGRAM

The 1981 field program was limited to infilling areas not previously mapped and rechecking some problem areas. Complete sampling was carried out in the Monkstown area of the Burin Peninsula and some infilling was carried out in the Stephenville - Port au Port area. Due to aggregate resource related problems, a detailed aggregate resource assessment was carried out within the Gros Morne National Park and a similar program is underway for the St. John's Urban Region plan area.

LABORATORY PROGRAM

The main thrust of the Laboratory program is the completion of analyses of all samples from previous years and to analyse the approximately 350 samples collected during the 1981 field season. In addition, pipette analyses are being conducted as time permits on all silt/clay samples collected during the past five years. Petrographic analysis on all pebble samples collected during the 1981 field season were completed. For a complete description of the analytical techniques used to analyse the aggregate samples in the field, in the laboratory and how the petrographic analysis was conducted, refer to Report 81-1 (Ricketts, *et al.*, 1981).

FUTURE PLANS

It is expected that in areas of high demand and/or low supply, a more intense investigation and detailed sampling program (Detailed Aggregate Assessment) will be undertaken. In areas where no additional sources of granular materials are located, a closer look

will have to be taken at tills and other nongranular materials to see if they can be beneficiated to an acceptable level for aggregate usage. In the future, a more intensive monitoring program will have to be undertaken to monitor existing and potential land use conflicts to ensure that aggregate materials do not become sterilized, and that they remain available to supply domestic and industrial constructional needs.

ACKNOWLEDGEMENTS

We wish to thank Martin Ricketts (geologist) Dan Bragg (lithological investigator), Bev Wareham (laboratory technician), Maurice Shephard (systems and procedures analyst), Tod Martin (field assistant) and all the other people who contributed to the project over the past five years.

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SURFICIAL AND GLACIAL MAPPING

SNOWSHOE POND, CENTRAL VOLCANIC BELT, NEWFOUNDLAND

by

B.G. Sparkes

INTRODUCTION

During 1981, mapping was conducted in the Snowshoe Pond (12A/7) map area (Figure 1). This project is a continuation of the provincially funded Surficial and Glacial Mapping Program in the Central Volcanic Belt, designed to provide information as an aid to mineral exploration (Vanderveer and Sparkes, 1979; Sparkes and Vanderveer, 1980; Sparkes, 1981). This area was chosen because of its recognized mineral potential and its recent exploration activity. The area has limited access and relatively few till exposures or unweathered bedrock exposures exhibiting glacial flow indicators.

FIELD PROGRAM

Mapping was started in June and continued until September. Information was obtained along existing roads, lake shorelines and streams. Sixty pits were dug to obtain samples and to provide suitable exposures to do till fabrics. During the summer, 200 sites were noted and 80 sets of striae recorded, with directions and/or relative ages assigned to most of these. There were 75 till samples taken for particle size analysis and geochemistry, and a representative pebble fraction was obtained to determine the lithologic composition of the tills. This lithologic study also included silt/clay coating, weathering, staining, sphericity, fracturing, mineralogy and texture for the various lithologies present.

Some work was also conducted in the Star Lake (12A/11) map area. This work consisted of doing till fabrics, and sampling some exposures which were found late in the 1980 field season.

PHYSIOGRAPHY

The terrain in the area varies from nearly barren, boulder-strewn, rock-ridged plateaus in the area to the south of Hospital Pond and to the west of Cowey Lake (underlain by intrusive rocks), to the drift covered (rib moraines, etc.) lowland areas to the north of Rodeross and Quinn Lakes (underlain by volcanics and sediments). The lowland area to the northwest of Meelpaeg Lake is characterized by sparsely vegetated rock ridges which have either a thin veneer of till or are boulder-strewn. The areas between these ridges are generally bog or swamp covered.

GLACIAL STRIAE

Throughout the whole area, a major set of striae at 160-195 (azimuth) has been recorded, and at two locations in the northwest corner of the map area, a second set at 250-270 was recorded on the same outcrop. In all cases where directions have been assigned to these striae, one or more of the following indicators have been used: (a) miniature crag and tail, (b) crescentic or lunate fractures or gouges, (c) nailhead features, and (d) miniature stoss and lee forms.

GLACIAL INTERPRETATION

The dominant flow of ice over this area was southerly (Map 1). This flow was usually towards 160 in the central to eastern part of the area and 180-195 in the western part of the map area. The source for this southerly flow was probably in the area of Red Indian Lake. At one location to the east of Rodeross

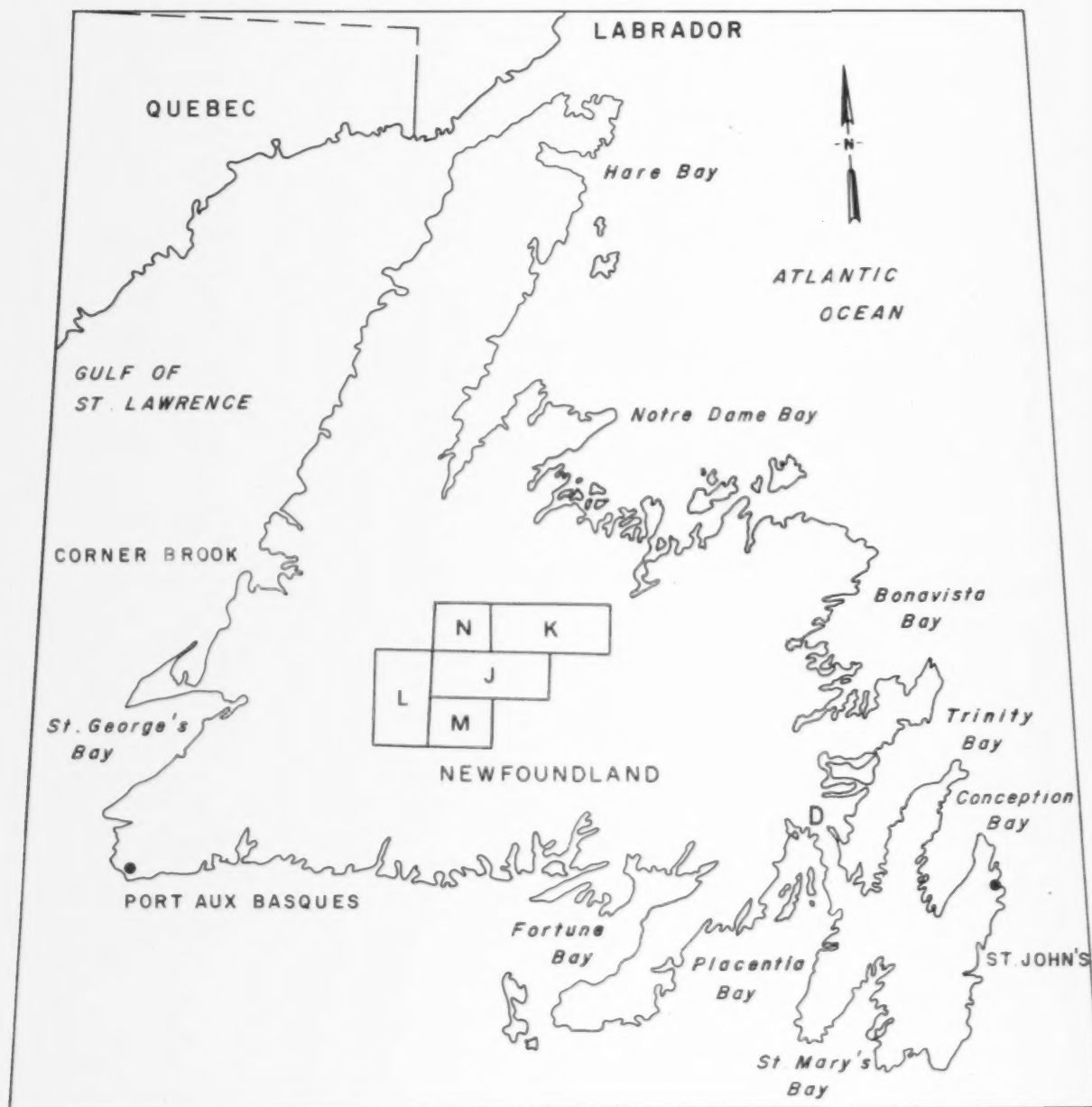


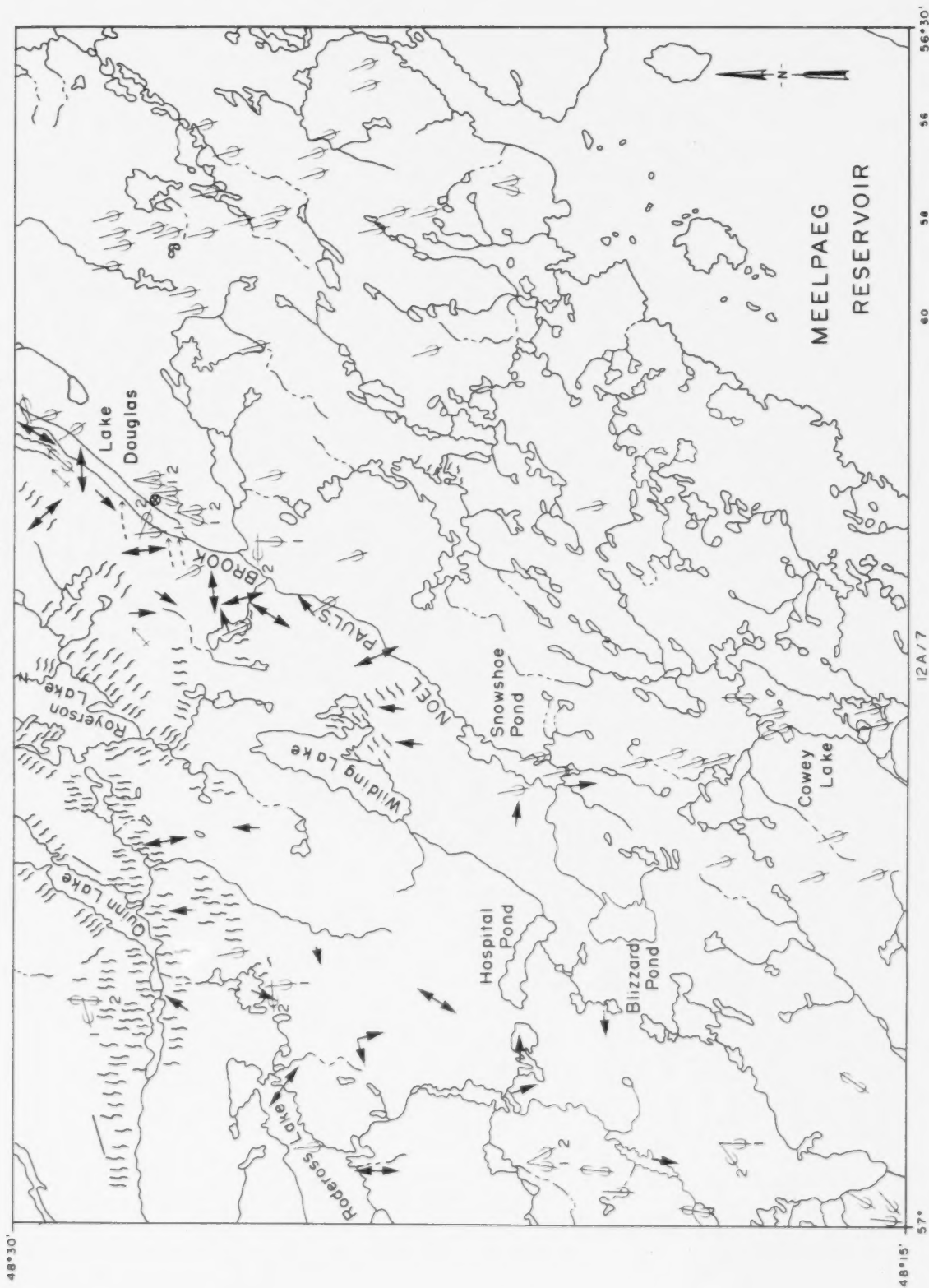
FIGURE 1

J. Lake Ambrose - Noel Paul's	(1978)	O.F. 12A (212)
K. Badger - Grand Falls	(1979)	O.F. NFLD (93)
L. Star Lake - Victoria Lake	(1980)	
M. Snowshoe Pond	(1981)	
N. Proposed Mapping	(1982)	

LEGEND

Glacial striae (direction of ice movement known, unknown)	
Number indicates relative age, 1 being the oldest	
Till fabrics (ice direction known, unknown)	
Esker (direction of flow known, unknown)	
Minor moraines, rib moraines, washboard moraines, annual moraines, till ridges transverse to ice flow (irregular, straight)	
Drumlins and drumlinoid ridges	
Glacial linear feature	
Glacial meltwater channel	

STAR LAKE GLACIAL FLOW FEATURES



Lake, crossing striae indicate a later westerly flow of ice, which may be related to the 250-270 flow recorded in the Victoria Lake map area (Sparkes, 1981), or may represent late stage topographic control of the southerly ice flow. Numerous transverse (rib) moraines in the area of Quinn Lake and Rogerson Lake been mapped and may be related to the northeast (060-070) flow of ice recorded in the Lake Ambrose and Noel Paul's Brook map areas (Vanderveer and Sparkes, 1979), although no northeast trending striae were found in the Snowshoe Pond map area. The absence of any northeasterly striae and the fact that the south trending striae (presumably older) are present could indicate that the rib moraines were formed at the front of the retreating southerly directed ice flow which became topographically controlled during its later stages.

ACKNOWLEDGEMENTS

The author thanks Jeff Steiner, Paul Sceard and Glenn Squires for their

diligent work and cooperation during the field season.

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PRELIMINARY GLACIAL MAPPING OF THE ACKLEY GRANITE - SOUTH HALF

by

D. G. Vanderveer

The southern portion of the Ackley Granite (Figure 1) covering parts of map areas 1M/10, 1M/11 and all of 1M/14 and 1M/15 was briefly surveyed following completion of an airphotography interpretation of the surficial landforms of the area.

The terrain in the area varies from barren outcrop with a thin or discontinuous mantle of glacial drift in the south and west to thick linear drift deposits and/or transverse (rib) moraine interspersed by substantial bog deposits in the central and northern parts of the study area.

Glacial transport throughout the Wisconsin appears to have been dominated by a general southern (180) glacial movement with an easterly or westerly component depending upon location.

In the eastern part of the study area (Terrenceville to Dunn's Pond area and north), this movement had an early easterly component between 140 and 160. During the later phases, this flow was either southerly (175-195) or more westerly (200-215) directed as the waning ice mass became more topographically controlled and was drawn

down into Placentia Bay and Fortune Bay respectively.

Flow in the western part of the area was dominantly southerly with minor variation due to topographic control or as the result of draw down into the many fjord-like embayments along the south coast.

The implications of glaciation on mineral exploration are as follows:

(1) West of Gisborne Lake, glacial transport has been dominantly to the south, the major difficulty would be determining the distance of transport when boulder tracing, etc.

(2) East and north of Gisborne Lake, the major landforms have a dominant east of south alignment, whereas striae record not only that movement but also later more topographically controlled movement to either the south or southwest, depending upon location. Prospecting and mineral exploration in this heavily drift covered area would be complemented by more detailed regional surficial and glacial mapping than was possible through this limited study.

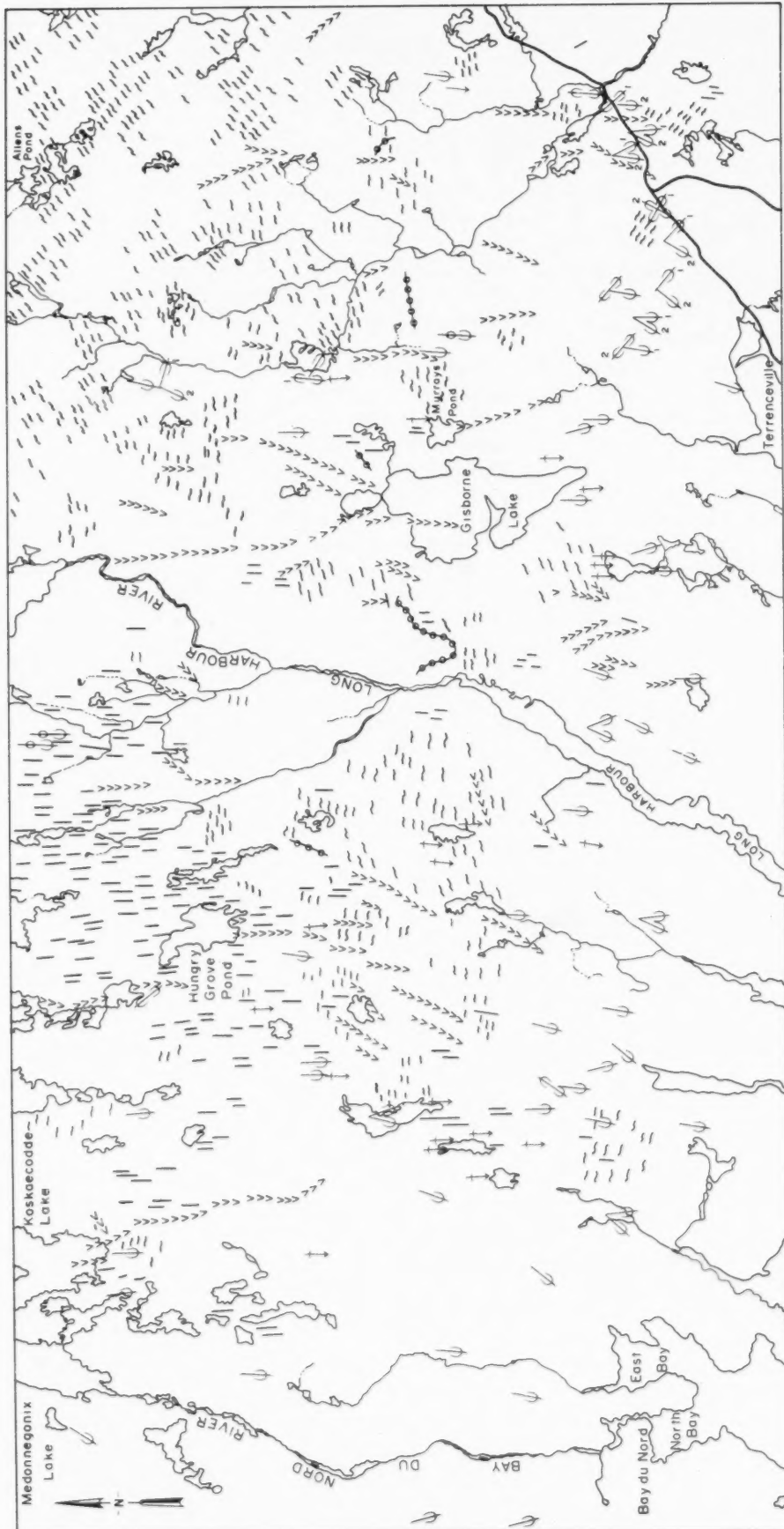


FIGURE 1

Preliminary glacial mapping of the Ackley Granite - south half,
South Central Newfoundland
D.G.Vanderveer 1981

LEGEND

- Major transverse moraines
- Minor transverse moraines
- Drumlin moraines
- Drumlinoid-linear moraines
- Crag and tail hills
- Esker (direction known)
- Stoss and lee on outcrop
- Glacial striae (direction known)
- Glacial striae (direction unknown)
- Striae - 1 oldest



RECONNAISSANCE GLACIAL MAPPING IN THE MELODY LAKE - ANNA LAKE AREA

LABRADOR

by

D.G. Vanderveer

At the request of Brinco, the author spent a few days investigating the glacial transport in the Melody Lake* and Anna Lake* areas of northeast Labrador, more particularly, parts of map areas 13J/12W and 13K/9E. The provision of meals, accommodation, and helicopter support by Brinex and the strong arms of Clayton Lyall are gratefully acknowledged.

Numerous boulders containing significant amounts of uranium mineralization have been located in the area. The determination of the effects of glacial movement and erosion on the transport of boulders from the source in bedrock would assist exploration in the area.

Glacial striae and landform features such as transverse (rib) moraine and lineated morainal features were mapped and two till fabric analyses (in 1 to 2 m deep hand dug pits) were obtained.

Glacial directions (striae, etc.) in the vicinity of the Anna Lake were generally to the northeast. One anomalous striae was observed to trend northwest-southeast, but by itself little significance can be attached to this striae. The geomorphological features in the vicinity of this prospect appear to be "ribbed moraine"

deposited transverse to the northeast direction of glaciation.

Near Melody Hill, glaciation is generally northeasterly directed, although minor variations were observed, these most probably being the result of local topographic influence.

The implications of glaciation and glacial deposition on mineral exploration in these areas are as follows:

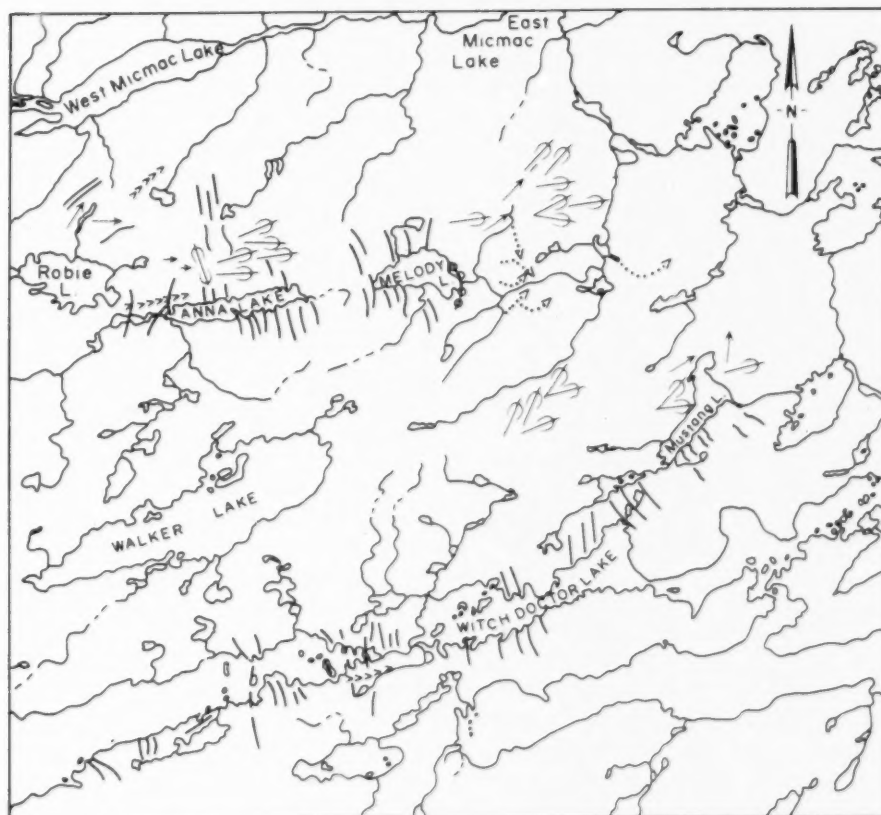
(1) The direction of glaciation is predominantly to the northeast although minor variations may be observed.

(2) Mineral exploration in this area is hampered by the lack of detailed quaternary mapping particularly as regards the distance and direction of glacial transport.

(3) The determination of the location of the mineralized boulders within the glacial "stratigraphic pile" would give an inference to the distance of transport, *i.e.* materials deposited as an ablation facies from an englacial or supraglacial position in the ablating glaciers may have been transported greater distances from the source than those materials deposited directly at or near the base of the ice.

*Unofficial geographic names, names assigned by Brinex

FIGURE 2
Preliminary Glacial Mapping of the Anna Lake-Melody
Pond Areas, Labrador
D.G. VANDERVEER, 1981



0 5 10 15
KILOMETRES

LEGEND

- | | |
|--|--|
| Major transverse moraines | |
| Minor transverse moraines | |
| Drumlin moraines | |
| Drumlinoid-linear moraines | |
| Crag and tail hills | |
| Esker (direction known) | |
| Stoss and lee on outcrop | |
| Glacial striae (direction known) | |
| Glacial striae (direction unknown) | |
| Striae - 1 oldest | |

DRILL CORE STORAGE PROGRAM

by

Alvin Harris

During 1979, the Newfoundland Department of Mines and Energy started a diamond drill core collection and storage program. The primary objective of this program is to provide well maintained and representative collections of drill core samples from as many drilling programs as possible for the future use of the mineral exploration industry, government geoscientists, university geoscientists and other geotechnical people.

I. Drill Core Collection

During the 1981 field season, the program of diamond drill core collection from abandoned drill sites in Insular Newfoundland was completed. All drill core in Insular Newfoundland that had been released by exploration companies or other owners and was salvageable has been collected. This past field season, fourteen sites were checked and 8,722.6 m of diamond drill core was collected. To date, the collection program has accumulated 55,873.9 m of core. Figure 1 shows the location of sites from which this core has been collected and Table I provides a summary of collected core.

Table II presents a summary of diamond drill core which was not recoverable. This core was not recoverable because it had been either dumped, vandalized or rendered unidentifiable and useless because of exposure to weather conditions over a period of years.

A comparison of core collected (55,873.9 m) and nonrecoverable core (42,145 m) shows a recovery rate of only 57% of drill core abandoned at drill sites.

The Department of Mines and Energy is presently considering a number of measures which could increase the recovery rate of core drilled in this province.

Included in the measures under consideration are the following:

(i) Confidential storage of company drill core in our core libraries. Confidentiality would be tied to land status and would be similar to the terms and conditions of confidentiality which presently apply to assessment reports.

(ii) Assessment credits to exploration companies to cover the cost of delivering core to our core libraries or to a road site where it may be readily collected by the core storage personnel.

It is anticipated that these measures, if implemented, would be sufficient to greatly increase the recovery rate of drill core and thereby enhance our collection. If you have drill core in safe, well maintained company storage facilities, *e.g.* at mine sites, base camps or active exploration sites, core storage personnel would like you to contact them as soon as you no longer need it.

II. Drill Core Libraries

The Department of Mines and Energy will be operating three drill core libraries after the construction and renovation program has been completed. These libraries are located in St. John's, Pasadena and Goose Bay (Figure 2).

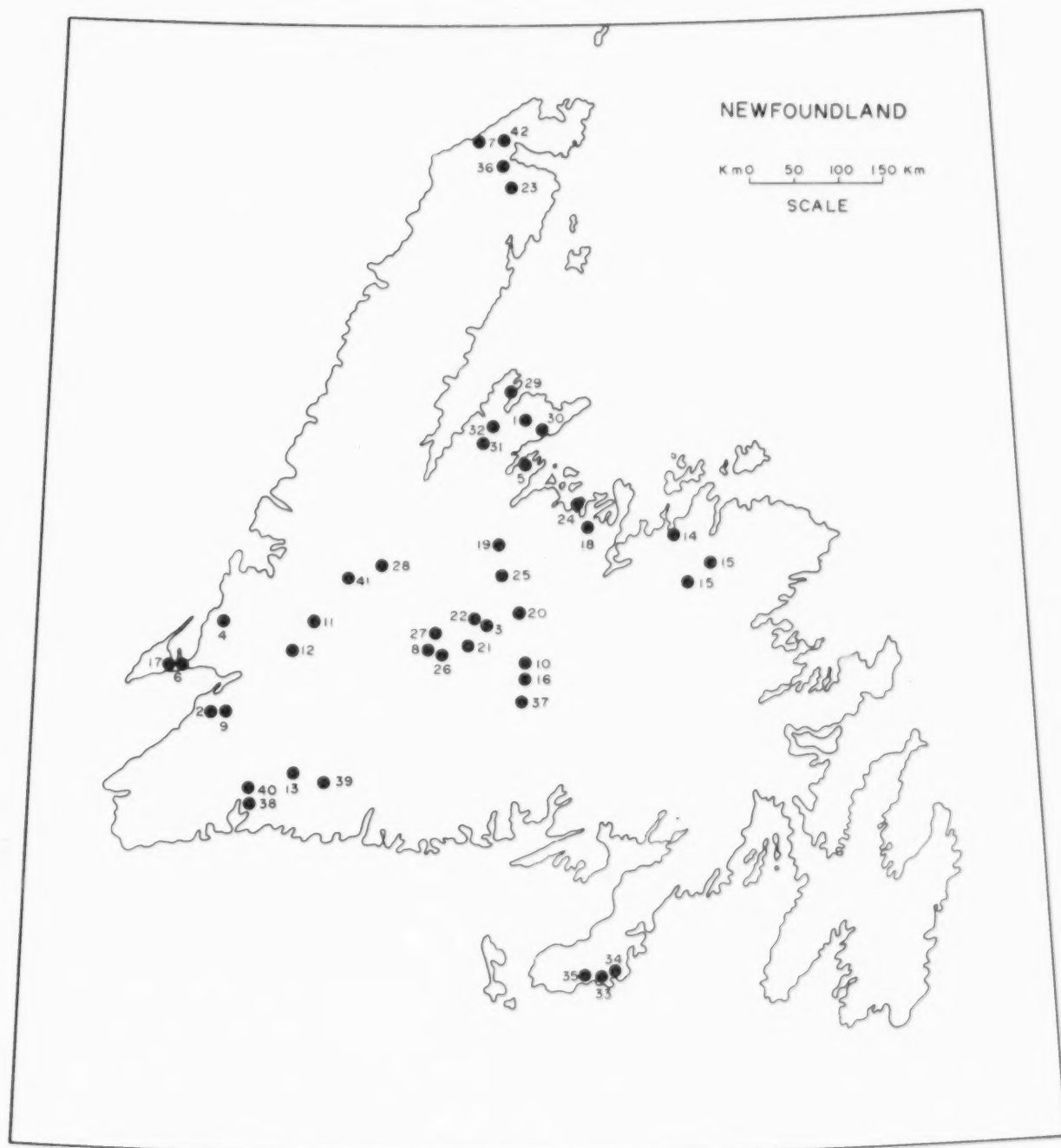


FIGURE 1. CORE COLLECTION SITES

TABLE 1: SUMMARY OF CORE COLLECTED TO DATE

No.	Company	Year	Property	# of Holes	Total Metres
1	Advocate	1967	Rambler	2	1,193.0
2	Anax	1976	Fischells Area	2	1,420.3
3	Amoco	1978	Burnt Pond	4	609.6
4	Beth Canada	1978	Springer's Hill	10	911.7
5	Boylen-Cerro		Colchester	18	1,379.2
6	Canadian Ref.	1970	Aguathuna	13	850.1
7	Chevron	1979	Eddies Cove	11	481.6
8	Cominco-Hansa	1973(?)	Bobby's Pond	5	431.6
9	Hooker Chemical	1968	Fischells	1	173.4
10	HBOG	1978	Gt. Rattling Bk.	11	818.6
11	HBOG	1978	Reid Lot 223	5	306.3
12	HBOG	1978	Reid Lot 225	2	117.0
13	HBOG	1978	Top Pond	1	47.1
14	Internat. Mogul	1974	Campbellton Area	15	1,394.5
15	Internat. Mogul	1975	Gander Area	12	708.7
16	Minorex	1978	Atlantic Lake	6	439.5
17	Nfld. Mines Br.		Port au Port	?	811.5
18	Noranda	1972	Point Leamington	3	265.8
19	Noranda	1973	Gullbridge	1	54.9
20	Noranda	1975	Leonard's Lake	3	388.6
21	Noranda	1975-78	Tally Pond	2	489.2
22	Noranda	1978	Burnt Pond	2	165.0
08	Noranda	1978	Bobby's Pond	4	320.6
23	Shell	1975-76	Main Brook Area	32	1,859.3
24	Texas Gulf	1975	Seal Bay	8	1,104.9
19	Gullbridge	?	Gullbridge	213	12,473.9
25	Consol. Morr.	1976	Lake Bond	2	419.1
26	L.M. & E.	?	Lake Ambrose	6	647.7
27	Kerr Addison	1974-75	Victoria Area	5	655.3
28	Shawmont	1977-78	Hinds Brook	28	822.9
29	Advocate	?	Priests Showing	8	774.8
30	Advocate	?	Nippers Harbour	7	946.1
31	Advocate	1976	West Pond	3	144.7
32	Advocate	1975	Flatwater Pond	11	907.6
33	ALCAN	?	St. Lawrence	?	8,153.4
34	D.S. Robertson	?	Mt. Margaret Area	?	4,463.8
35	D.S. Robertson	?	Lawn Area	?	
36	Noranda	?	Round Pond Area	?	?
37*	RIOCANEX	1976	Cold Spring Pond	1	30.0
38**	Falconbridge		Strickland Property	?	4,427.2
39**	Falconbridge	1981	Burgeo Road	16	1,059.2
40*	Long Lac Min.	1968	Strickland Property	18	975.3
41*	Minorex	1978-80	Deer Lake	25	1,993.3
42*	U.S. Borax	1979	Hidden Pond	11	237.6

TOTAL: 55,873.9 m

* Collected in 1981

+ In temporary, Confidential Storage

TABLE II: SUMMARY OF NONRECOVERABLE CORE

Company	Year	Property	# of Holes	Total Metres
Asbestos Corp.	1946	Lewis Hills	6	614
Asbestos Corp.	1947	Lewis Hills	11	804
Asbestos Corp.	1947	Lewis Hills	5	178
Atlantic Coast Copper	1961	Lady Pond	4	310
Atlantic Coast Copper	1962	Lady Pond	4	396
Atlantic Coast Copper	1964	Lady Pond	1	122
Atlantic Coast Copper	1967	Little Bay	2	419
Atlantic Coast Copper	1968	Little Bay	5	783
Atlantic Coast Copper	1968	Little Bay Mine	15	4,264
Canadian Johns Manville	1976	Baie Verte-West Pond	18	1,778
COMINCO	1947	Tilt Cove	11	2,448
Kerr Addison Mines	1972	Crooked Pond Grid	3	267
Kerr Addison Mines	1972	Rambler South #1	3	219
Kerr Addison Mines	1972	Rambler South #3 Grid	?	31
Kerr Addison Mines	1972	Rambler South #2 Grid	?	61
Kerr Addison Mines	1973	Flatwater Pond Grid 'F'	2	175
Kerr Addison Mines	1973	Flatwater Pond Grid 'A'	1	115
Kerr Addison Mines	1973	Rambler West Grid #1	2	214
Kerr Addison Mines	1973	Rambler South Grid #1	3	363
Kerr Addison Mines	1973	Rambler South Grid #2	2	214
Kerr Addison Mines	1973	Crooked Pond Grid	4	541
Kerr Addison Mines	1973	Rambler South Grid #3	11	1,553
Kerr Addison Mines	1973	Green Cove Grid	1	90
Kerr Addison Mines	1973	Flatwater Grid G	1	98
Kerr Addison Mines	1973	South Brook Grid #1	1	152
Kerr Addison Mines	1973	Rambler South #3 Ext.	8	1,149
Long Lac Min. Expl.	1969	York Harbour	13	1,601
Long Lac Min. Expl.	1970	York Harbour	140	3,734
McIntyre Porcupine Mines	1968	Gull Pond	7	785
M.J. Boylen Eng. Co.	1956	Miles Cove	13	1,671
NALCO	1970	Sleepy Cove	3	136
NALCO	1956	Lockport	9	1,144
NALCO	1968	Lockport	3	699
New Jersey Zinc	1956	Lake Bond	21	4,016
New Jersey Zinc	1955	Lake Bond	6	207
New Jersey Zinc	1955	Lake Bond	4	591
Noranda	1975	Sandy Lake	2	183
Noranda	1969	Hinds Brook	1	65
Noranda	1974	Burnt Pond	10	1,365
Noranda	1975	Tally Pond	9	1,305
Noranda	1976	Tally Pond	7	969
Northern Canada Mines	1964	Hearn Property	4	347
Texas Gulf	?	Trail Pond	1	56
Allied Chemical Corp.	1972-73	Rocky Pond	2	405
Allied Chemical Corp.	1972-73	Anchor Droque	15	1,989
Allied Chemical Corp.	1972-73	Shearstick Brook	4	311
RIOCANEX	1976	Cold Spring Pond	4	634
New Jersey Zinc	1970	Main Brook Area	7	1,494
COMINCO	1966	Canada Bay	3	83
Long Lac Min. Expl.	1968	Strickland Property	?	620
NALCO	1954	Spar Pond	4	377

TOTAL: 42,145 m

FIGURE 2
PROVINCE OF
NEWFOUNDLAND

M: 20 0 20 40 60 80 100 Mi

■ CORE LIBRARIES



The St. John's core library is now fully operational and is staffed on a full-time basis, except during the field season. Approximately 10,000 m of drill core has been cataloged and placed on the rack system in the St. John's library. Most of this core is from the St. Lawrence area. Drill hole logs and location maps have been prepared for cataloged core. The St. John's library contains rock cutting equipment, core splitters, a stereomicroscope, a magnetic susceptibility meter, a resistivity meter, an ultraviolet light and a McPhar TV-1 scintillometer. These facilities and equipment are available for use on approved projects by exploration geologists, university researchers, the staff of the Department and other interested persons.

The Pasadena core library is presently under construction and is expected to be operational by July, 1982. This library will contain equipment and facilities similar to the St. John's library, but will have a capacity of 200,000 m of core; the St. John's library has a capacity of about 60,000 m of core. The Pasadena library will have facilities for storing radioactive core and a humidity controlled room for storing salt core.

A contract was let in late 1981 for the renovation of an existing building (#54) in Goose Bay to convert it to a drill core library. This building will have an initial capacity of 60,000 m of drill core, with space available for future expansion. Renovations to this building are expected to be completed by the summer of 1982. The building is presently available for storage of drill core in parts of it not being renovated.

III. Future Plans

Future plans include moving drill core from temporary storage sites in Pasadena and Springdale into the Pasadena library and a drill core collection program in Labrador during the 1982 field season. A computerized diamond drill hole index (inventory) system is being developed, and drill hole logs and location maps will be made available in published form when all three core libraries are fully operational.

We encourage all companies now drilling or planning drilling programs to contact us about drill core storage. Store with us and save yourselves the cost of facilities.

GEOFILES - MICROFICHE PROJECT

by

N. Mercer

The Mineral Development Division maintains a geological and mineral resource assessment file system commonly referred to as the "Geofiles". The geofiles presently consist of approximately 8,500 geological reports, maps, journal articles, and mineral assessment files, making them the largest and most comprehensive collection of geoscience documents on Newfoundland and Labrador to be found anywhere.

With the current high level of mineral exploration activity throughout the province, the amount of new data being submitted continues to increase substantially. This trend is expected to continue over the next few years, as more land comes open for claim staking and as new geological and geochemical reports and maps are published by the Mineral Development Division on the mineral potential of various regions of the province.

Mining and exploration companies, geotechnical and consultant firms, government agencies, universities, libraries and the general public are continually making use of the geofiles and requesting information from them. Requests for information have tripled in the past few years.

During the past 2 years, the Publications and Information Section has been putting all of the geofiles on microfiche. This will provide a much more efficient system of maintaining the geofiles. Requests for information will be handled much easier, with relatively inexpensive charges for files.

The project has involved daily filming of batches of files. The files are cross-checked before filming for

quality, content and reproducibility. Two fiche originals are made for each file and are cataloged and placed in microfiche file cabinets. Filing follows the standard NTS system presently used in the Department. Duplicates can be copied from the original fiche upon demand. One set of fiche originals for the geofiles will be stored offsite for security and fire protection.

Presently, over 90% of the microficheing has been completed on the project. The remaining work consists essentially of cross-checking for old and missing files and having old reports retyped and poor quality maps redrafted. Attempts will be made to obtain old company data from various mining company offices. Also, each month, new assessment files and publications which have been received are microfiched to keep the geofiles up-to-date.

Over the past year, the Department has been providing microfiche copies of new open files and reports as they become available. Also, a number of requests from mining companies for geofile data have been filled with microfiche. During 1981, microfiche viewers and readerprinters have been obtained which can handle both reports and maps (16 mm and 35 mm).

This past year, microfiche copies of nonconfidential geofiles have been made available for several areas on the Island. These releases pertain to those open geofiles that have produced top quality film. There will be further updates to these initial releases as other files are upgraded to produce good quality microfiche.

Microfiche of files on map areas 1K, 1L, 1M, 1N, 2C, 2F, 2L, 2M, and 2D

are on sale now at a total cost of \$342.00 per set; files for area 2E will be released shortly. We expect to complete the rest of the Island during the first half of 1982, at least for initial releases.

For more information on the microfiche project, please contact Norman Mercer (709-737-3159). We look forward to your comments and suggestions.

ACKNOWLEDGEMENTS

Bob Muggridge and Brian Fleming are thanked for their work on the microfiche project over the past 2 years.

The Department of Mines and Energy acknowledges the continued participation and cooperation of Ches Hapgood and staff of the Micrographic Section, Department of Public Works and Services, on the microfiche project, especially in filming and duplicating the geofiles.

GEOSCAN - THE NATIONAL DATABASE FOR GEOLOGICAL INFORMATION:

'THE NEWFOUNDLAND CONTRIBUTION'

by

C. Patey

GEOSCAN is a computerized bibliographic database of Canadian-produced and/or Canada-related geoscience documents. It is updated several times a year at the computer facilities of the Federal Department of Energy, Mines & Resources, Ottawa, with input from several contributing agencies.

The Newfoundland Department of Mines & Energy is one of the ten presently participating agencies who produce indexed documents. The 'geofiles' and the mineral inventory cards at the Publications and Information Section are the source of our indexed documents. As of July, 1981, there were 6,173 documents in GEOSCAN from this agency and 6,680 documents in total that concerned Newfoundland. This discrepancy exists because other agencies, e.g. the Geological Survey of Canada, produce and index documents that concern this province. In the three updates for 1981, 277 new documents were added. These represent mainly assessment files and serial literature, with some government reports and maps, theses and consultant reports.

The Canada Centre for Geoscience Data (C.C.G.D.), who manage GEOSCAN, are presently implementing a new software system called MINISIS. It has not yet been determined what new services MINISIS will provide. Since the February, 1981 update, the emphasis has

been on examining and correcting existing documents so that they will transfer easily to the new system. This combined with a review of many geofiles has resulted in numerous changes. These include:

- (a) Addition of more NTS grid locations,
- (b) release of confidential documents (300 newly opened geofiles!),
- (c) some geofile number changes,
- (d) some map file number changes, and
- (e) deletion of 138 geofiles because of duplications, nongeoscience material, grossly incomplete material, etc.

Usually, once a year, we arrange with C.C.G.D. to produce some custom indexes from GEOSCAN. The most popular have been the NEWFOUNDLAND/LABRADOR - NTS INDEX and the NEWFOUNDLAND/LABRADOR - KEYWORD INDEX. This year, in order to increase the availability of these products, we arranged to get the original microfiche for both of these indexes and to produce duplicate microfiche copies at the Newfoundland Department of Public Works. The indexes were ordered after the February update. The original microfiche (NTS and KEYWORD INDEXES) arrived on May 15th, and the 19 paper copies (NTS only) arrived on May 19th.

INDEXES, FEB., 1981	SIZE	COST	UNITS SOLD UP TO OCTOBER 6TH, 1981
NTS PAPER	1,062 PAGES	\$30.00	11
NTS MICROFICHE	16 MICROFICHE	8.00	17
KEYWORD MICROFICHE	90 MICROFICHE	45.00	15

For the NTS (paper) Index, there is a sample copy in a new 'reduced format'. It is less bulky, with smaller print and one-half the number of pages as the usual index. If there is enough interest in this new format, more can be ordered.

These indexes are for the benefit of you, the user. We welcome suggestions for improvement and appreciate being notified of any errors or discrepancies you discover.

As well as these products, GEOSCAN is available in the form of online computer searches through the Library of the Geological Survey of Canada as well as the Newfoundland Department of Mines and Energy. Searches are performed on a

cost recovery basis with a minimal charge of \$10 per search topic. A moderate size search (100-200 titles) would cost between \$15-\$45. However, because of plans to switch to MINISIS, the online system has not been updated since February, 1979; therefore, all GEOSCAN articles since that date would not be included in such a search.

The new system, MINISIS, should solve this as well as other problems, and make GEOSCAN a very reliable tool in our search for new mineral resources.

For further information on GEOSCAN, please contact Catherine Patey (709)737-3159. We look forward to your comments and suggestions.

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